THE RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

PUBLISHED MONTHLY AT No. 145 BROADWAY, NEW YORK.

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FREDERICK HOBART. . . . . . Associate Editor.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid	$3 00
Subscription, per annum, Foreign Countries	3 50
Single copies	25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

NEW YORK, JANUARY, 1890.

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THE sudden and mysterious death of Franklin B. Gowen removes a man who, a few years ago, was one of the most prominent figures among railroad managers. Although, since his retirement from the presidency of the Philadelphia & Reading Company three years ago, he had confined himself entirely to the practice of law, he was so active and brilliant a man and so much given to unexpected *coups*, that no one knew when he might return again to the railroad field. That he should die by his own hand, which seems to have been the case, was to his friends something altogether inexplicable, for he was not a man given to despondency, but, on the contrary, of an exceedingly sanguine and hopeful disposition, while he was also well provided with money and reasonably happy in his domestic affairs.

Mr. Gowen was never a practical railroad man, but rather a lawyer and a man of affairs, although his active and many-sided mind enabled him to grasp more of the practical part of railroading than most men of his class. Brilliant as he was, however, and successful as he was in many of his undertakings, his administration of the Reading's affairs must, upon the whole, be considered to have been a failure. He raised the Reading, it is true, from the rank of a successful local company to be one of the great railroad corporations of the country, but he brought it to bankruptcy and left it in a condition from which it will not recover in years, if, indeed, it ever does. In fact, his great weakness lay in the very sanguine disposition already referred to, which led him to anticipate too much from the future, and to take too little account of the obstacles to success. He was undoubtedly a man of the greatest ability, but the Reading stockholders might well have been satisfied with a less brilliant career than he had marked out for the company.

Personally, Mr. Gowen was an upright man, and his bitterest enemies never charged him with anything approaching a dishonest use of his position. His great strength was in his wonderful powers of persuasion, by which he retained so long his influence over the Reading stockholders and his position at the head of the company. Few men could resist him in a personal interview, and, when he was practising law, few cared to meet him at the bar.

A REMARKABLE time record was made on December 1 last on the Southern Pacific Railroad. On that day a special train, consisting of two cars containing officers of the Atchison, Topeka & Santa Fé Railroad, was run over the Southern Pacific lines from Bakersfield to Lathrop, a distance of 220 miles, leaving the former place at 9:01 and reaching the latter at 1:18; the total time was thus 4 hours, 17 minutes, but of this time 35 minutes were lost in making four stops and in slowing down on account of a broken frog at a station, making the actual running time for the 220 miles only 222 minutes, and it is claimed that even this could have been improved had not the road-bed been in poor condition, owing to recent heavy rains. It is claimed that this is the longest run ever made in this country at a speed of 60 miles an hour, and—speaking from memory and without consulting the records—we think that the claim is justified. The greatest speed attained for a single mile was betweeen Berenda and Merced, where one mile was made in 45 seconds, or at the rate of 80 miles an hour. The best time for a stretch of several miles was from Tulare to Goshen Junction, 10.5 miles, which, as shown by the despatcher's sheet, was made in exactly 8 minutes. Assuming the speed to have been uniform, this was at the rate of one mile in 45.7 seconds, or 78¾ miles an hour. This extreme speed was required to compensate for the slow time made in crossing the long bridges over the Kern, the San Joaquin, the Merced, the Tuolomne, and the Stanislaus rivers.

The engine which did this very fast work was an ordinary 8-wheeled locomotive with cylinders 17 × 26 in. and drivers 5 ft. 10 in. in diameter, built in the Sacramento shops, in 1885, from the designs of the late Mr. A. J. Stevens, and provided with his valve-motion. The engine burned 3½ tons of coal in making the trip, and the tank was filled twice with water during the run. Some careful work was done by the train despatchers in keeping the track clear for the special.

At Lathrop the train was taken by another engine of the same size, but the run beyond that point was not an extraordinary one, although still pretty fast, the distance from Lathrop to Oakland Pier, 90 miles, being covered in only 105 minutes, or at the rate of 51.43 miles an hour.

THE terminal facilities of the Baltimore & Ohio Railroad in Baltimore are to be very much improved when the arrangements which the Company has made are carried out. The first of these consists in the establishment of a great freight-distributing station at Berlin, Md., 70 miles from

Baltimore, a place which has been selected because it is east of the junctions of all the branches and connecting lines of the system. The general distribution of freight, both east and west-bound, will be made here, and the yard, which will be arranged in the best manner, will be the central point for making all freight trains. This will greatly relieve the yards in and near Baltimore, and will take the distribution of freight entirely out of the city.

The second improvement will be by the construction of what is known as the Baltimore Belt Railroad, which will start from a point near Camden Station, thence by a double-track tunnel under the city to Jones' Falls, and thence to the eastern boundary of the city. It will connect the main line with the Philadelphia Division of the road without the present inconvenient transfer, and will enable both freight and passenger trains to be carried through and around the city without delay. It is understood also that it will serve as a connection with the Western Maryland and the Maryland Central Railroads, and with a large union station at a point much more convenient than the present Camden Station will be.

A NEW plan for the disposition of the Chicago terminal difficulties and for avoiding the delays now incident to the transfer of freight in that city is proposed by a corporation, organized under the name of the Chicago Union Transfer Company. This plan is to establish at a point south of the city, where convenient connections can be made with the Chicago & Western Indiana and the Outer Belt railroads, a series of extensive yards connected by a circular railroad. To these yards all transfer freight would be brought, and all switching would be done there, the amount of switching being reduced to a minimum, the transfers promptly made, and the present delays and inconveniences wholly avoided. The Transfer Company would also act in the capacity of a clearing-house to conduct the business between the different companies. The plan seems a very feasible one, and there is no doubt that it can be carried out successfully, provided all the railroad companies concerned give their assent; several, it is said, have already done so. Some such arrangement as this is really essential to the proper conduct of business at Chicago.

IN Sweden and Norway, as in many other countries, there has been much activity in railroad building for the last two or three years, both from private enterprise and by the Government. The Swedish Parliament has more than doubled the annual grant for the construction of new lines in 1890, and work is proceeding rapidly on several important roads, especially on those extending to the northern part of the kingdom and intended to develop the resources of that section, which has hitherto been somewhat neglected.

THE latest country to enter the field as a builder of railroads is Siam, as will be seen from an article published in another column. Heretofore there have been no steam railroads in that country, and the only line of any description has been a street tramway in the city of Bangkok.

As will be seen from the article, it is proposed to begin in a moderate way, and there is every reason to hope for the success of the Borapah Railroad Company, which is the pioneer in the work. It is to be regretted that from present indications the orders for material and rolling stock will go to European manufacturers, as a new field might be opened to our own car and locomotive-builders, which in time might prove to be of considerable value to them, as the country is capable of much development.

THE truth about Chinese railroads, which, as was noted in our last number, has been somewhat difficult to get at, seems to be that for the present railroad construction is stopped, the conservative and anti-progressive party, which is strongly opposed to foreign loans and to the introduction of foreign methods, being temporarily in the ascendant at Pekin. From accounts received from China, it seems that this party has taken advantage of the accidental destruction of the Temple of Heaven by fire started by lightning, to excite the superstition of the Emperor and his chief councillors, and that this accidental fire has been interpreted as a visitation of divine vengeance, consequent upon the imperial order sanctioning the building of railroads. The superstition inherent in the Chinese character has thus been used shrewdly by the conservative leaders to further their purposes.

The sanction for the construction of the railroad, it appears, has not yet been formally revoked, but the whole question is, for the present, in abeyance. The progressive party, headed by the Viceroy Li, may be relied upon, however, to make every possible effort to secure the construction of the railroad; but for the present it is very doubtful whether they will be able to do anything.

THE decision—or rather opinion—of the International Railroad Congress does not seem to have been altogether favorable to the compound locomotive. That opinion, which will be found on another page, was to the effect that while a certain success has been attained with compound locomotives, it is not yet by any means sure that the economy in fuel which has been secured is not counterbalanced by the disadvantages inherent to the greater complication of the machinery and by the extra cost for repairs and lubrication. The Congress, however, admitted that there might be a balance upon the right side in countries where fuel is expensive, and advised a continuance of the experiments, so that the question may still be considered an open one.

AS will be seen from the extracts from his report, which are published on another page, the present Secretary of the Navy does not favor any considerable increase at present in the number of cruisers in the Navy, but thinks that its further development should be in the direction of heavy armored battle-ships adapted to fight for the defense of the coast. A battle-ship is of use only for naval purposes, but for cruisers, he thinks, fast vessels can be supplied in case of war from a naval reserve—that is, from merchant ships, so built that they can be armed and used as cruisers when required. There are strong arguments in favor of this plan, and the chances are that it will at least be given a trial.

IT is understood that the Navy Department is considering a change in the armament of the coast-defense vessel, which is now under construction at the Union Iron Works in San Francisco. The original design provided for one 16-in., 110-ton rifled gun in the forward turret; one 12-in.,

46½-ton gun in the after turret; and a 15-in. Zalinski dynamite gun forward. It is now proposed to substitute two 12-in. guns for the 16-in. gun in the forward turret, and to use a 10-in. instead of a 12-in. gun in the after turret. It is possible also that the dynamite gun may be omitted. These changes have not been finally decided upon, but are under consideration.

Experience with the 110-ton guns in England has not been sufficiently encouraging to warrant the introduction of these very large guns. They are exceedingly expensive, and it appears to be a very general opinion among foreign naval authorities that these enormous guns are of very doubtful utility, and that in most cases better service can be done by two or three guns than by one of the largest size.

THE Secretary of the Navy has ordered that the new coast defense vessel now building in San Francisco shall be called the *Monterey*, that name being chosen because Monterey was the point where the United States flag was first raised in California.

The new torpedo-boat will be named the *Cushing*, in memory of Lieutenant Cushing, who first demonstrated, on the Confederate iron-clad *Albemarle*, at Plymouth, N. C., the power of a torpedo attack.

NAVY bills are already plenty in Congress, and the first one, which has been introduced in the Senate by Mr. Hale, of Maine, provides for the construction of no less than 18 new ships. In accordance with the ideas laid down in the report of the Secretary of the Navy, no more cruisers are included in the number, which is made up of eight heavy armored ships of from 7,500 to 10,000 tons displacement; two armored ships for coast defense; three gunboats of from 800 to 1,200 tons displacement; and five torpedo-boats of the first or sea-going class. How far this programme will be approved by Congress remains to be seen.

ANOTHER bill, introduced by Mr. Hale, is also apparently based upon the Secretary's report, and provides for establishing a naval reserve of merchant vessels built in accordance with the requirements of the Government, and of sufficient engine power and stability to carry guns, and to be used as cruisers in time of war. The compensation proposed for building ships in accordance with these requirements is a percentage payment for "trouble and expense incurred in complying with the conditions of the Government." We do not give any fuller statement of these bills, as they will probably be modified considerably before their passage.

THE Ordnance Department of the Army proposes to make extensive improvements at the Watervliet Arsenal this year, and has asked for appropriations of $249,000 for completing the building for the large gun factory, and $888,500 for machine tools, cranes, etc., for the factory. With this additional plant six 16-in. and ten 12-in. guns can be turned out yearly in addition to the smaller guns now manufactured. Should the appropriations be obtained it is thought that the Arsenal can be ready to make 16-in. guns by the time the forgings for those guns could be delivered.

Besides making the new guns the Department proposes to continue the alteration of the old 15-in. guns and the conversion of the 10-in. guns into 8-in. rifle cannon, with the alteration of the old carriages for the more modern guns. It is also proposed to continue the experiments with armor-piercing projectiles, and with smokeless powder.

THE building of new ships for lake business is very active this fall, nearly all the ship-yards on the lakes being busy, and in Cleveland alone 15 large steamers are under contract, 12 of them being of steel. Nearly all of these vessels are intended for ore and grain carriage, and are of the type common of late years on the lakes, with great capacity for cargo, and with machinery of the latest and most economical type, the engines being generally of the triple-expansion pattern.

In one respect there is a new departure this fall, Wheeler & Company, of Bay City, having undertaken to build two steamers for ocean service. These ships are to be of steel, to have a capacity for 3,000 tons of cargo each, and are built for the Chesapeake & Ohio Railroad Company, to run from Newport News. They will be built in sections so as to pass readily through the Welland and the St. Lawrence canals.

THE NEW YORK CENTRAL ACCIDENT OF SEPTEMBER 27, 1889.

IT will be remembered by most of our readers that an accident occurred some months ago on the New York Central Railroad, which was caused by the second section of the fast Chicago express running into the rear end of the first section near Spraker's Station, and that four persons were killed and eight were injured. We omitted making any comment thereafter because the subject was under investigation by the Railroad Commissioners of New York State. The Commissioners made their report on November 12, but for some reason a copy of it did not reach us before the December number of the JOURNAL went to press. Although our comments thereon are somewhat belated, we will, nevertheless, have our say.

The train was made up as follows: 1. Locomotive; 2. Baggage car; 3. Coach; 4. Coach; 5. Coach; 6. Sleeping car; 7. Special car *Kankakee*; 8. Michigan Central private car.

The Commissioners report that:

> The second section crashed into the end of the private car of the Michigan Central road. The rear of this car, for about 10 ft., was fitted up as an observation room, and was crushed through about 8 ft. The remainder of the car, owing to its unusual strength, was comparatively uninjured. The car ahead, the *Kankakee*, occupied by the President of the Cleveland, Cincinnati, Chicago & St. Louis Railroad and others, was injured comparatively little. It appears that *the rear end of this car was pressed down, tilting up the forward end, which telescoped the sleeping car ahead of it.** The *Kankakee* was some 8 or 10 in. narrower than the sleeping car. If the frame of the *Kankakee* had been the same width as that of the sleeping car, it is probable that little or no injury would have been done. As it was, however, the resistance that it met was only from the interior construction of the sleeping car. The dead and the wounded were all found in the latter car, except the porter of the *Kankakee*, who was in the forward part of that car, and was killed when the telescoping took place.

The Board concluded that the principal cause of the accident "was the rule of the New York Central & Hudson River Railroad Company, permitting these sections to

* Italics ours.—EDITOR JOURNAL.

be run at as close an interval as five minutes; . . . and the Board is of the opinion that the interval of time is too short."

They recommend that the interval be made 10 minutes, that the Railroad Company take into consideration the subject of equipping the entire line with block signals, and that brakes be applied to all the wheels of six-wheeled trucks.

The Railroad Company would do well to act in accordance with these recommendations, but some of its officers, and perhaps the Railroad Commissioners also, might do well to heed some of the recommendations of the RAILROAD AND ENGINEERING JOURNAL.

In the JOURNAL for February, 1887, we published the following description of the Blackstone platform:

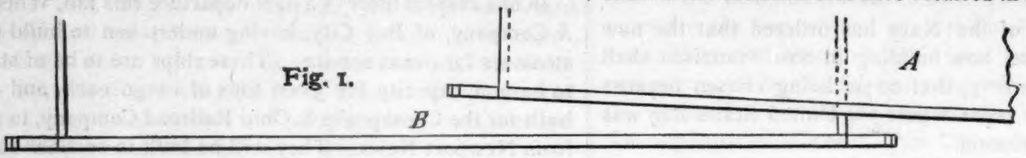


Fig. 1.

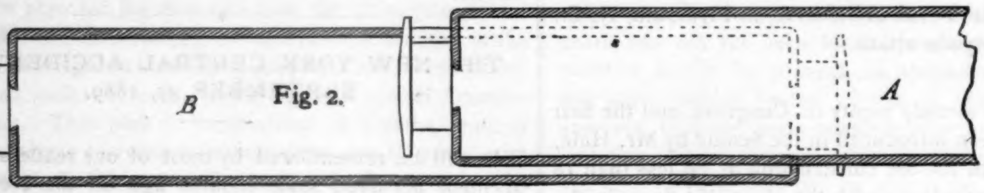


Fig. 2.

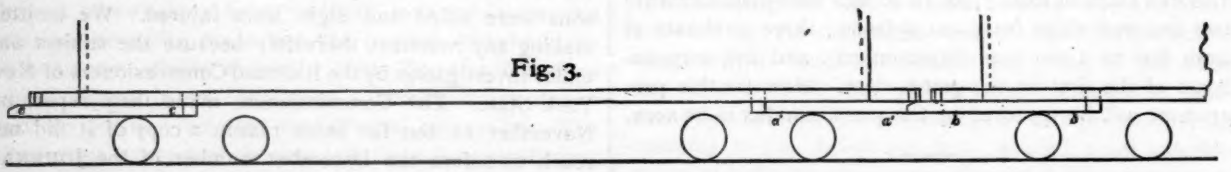


Fig. 3.

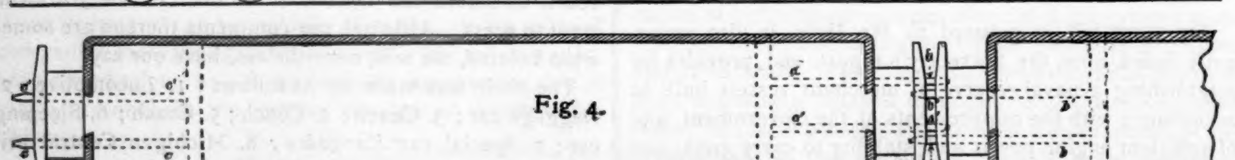


Fig. 4.

It was supposed that when the Miller platform was introduced it would entirely prevent the telescoping of cars; but recent accidents have shown that such is not the case. No doubt the Miller platform will resist shocks which would have crushed the old-fashioned cars which were used before it was introduced; but what generally occurs in collisions now is that the floor of the one car mounts above that of the other, as shown in fig. 1. The position of the two car bodies is shown in a plan view in fig. 2. It will be seen that when the cars get into this position, the only thing which resists the car *A* from crushing or telescoping with *B*, is the side *s s*. This consists of posts and panels and has very little strength. If, however, the floors of the cars could be kept in line, or the one be prevented from raising above the other, then the shock would be resisted by the longitudinal sills in the floor, which have a great deal of strength. What is needed, therefore, is some device to keep the floors of the cars in line, and prevent the one from raising above the other. Happily, we have not far to go to find such a device. The Blackstone platform and coupler have been in use on the Chicago & Alton Railroad for some 15 years or more. Of the coupler no other mention need be made. The peculiar feature of the platform referred to is shown by fig. 3, which is a side view, and fig. 4, a plan of the floor framing. Each car has two "horn timbers," *a a, a' a'* and *b b, b' b'*, which project beyond the buffer-beams, and are fastened below the floor-sills. The horn timbers are not placed at equal distances from the center of the car, but one is farther from it than the other, so that when one car adjoins the other, as shown on the right side of fig. 4, the safety-beams interlock, as shown. It will also be seen that those in the one car project under the buffer-beam of the other, so that the one car cannot raise up without taking the other with it. In this way the floors are kept in line, and the longitudinal beams, instead of one side only, must resist the shock of collision. The side has little more capacity of doing so than the paper in hoops has of opposing the leaps of a circus-rider.

These horn timbers were invented by Mr. Blackstone, President of the Chicago & Alton Railroad Company. As safety-guards, in case of accident, they appear to have as much value as the Miller platform, although there is no reason why they should not be used conjointly. Probably if Mr. Blackstone had urged the adoption of his invention with the same vigor, and with the same methods, that were employed to make the Miller platform known, the former would now be as generally used as the latter is. There is little doubt that if the Blackstone device had been adopted, we would have been spared the horrors of some of the accidents that have occurred in recent years.

In the May number of the same year a complete engraving of this invention was also published, with the following comments:

A common impression prevails that Miller platforms are an effectual preventive of telescoping. Many accidents have shown that such is not the case. The Miller platform has very little, if any more, capacity to resist concussion if the cars are not kept in line with each other than the old-fashioned cars had. The only thing which prevents cars with Miller platforms from mounting on top of each other in collisions is the draw-hook, and this is usually so insecurely fastened that it has comparatively little strength. The "horn timbers" which Mr. Blackstone has devised can be made with any amount of strength, and, it is believed, would do as much to prevent telescoping as the Miller platform has or will. Probably a good many more lives will be sacrificed before the value of this device will be generally recognized. It would not require very great prescience to prophesy that other horrible accidents will occur in the not very remote future, in which a good many lives will be sacrificed and which will cause inexpressible suffering—all of which might be prevented by the adoption of the simple device illustrated in the engravings, and which any company is now at liberty to use.

The last sentence might appropriately be set up with the following heading:

PROPHECY

From the Railroad and Engineering Journal of May, 1887.

and be held in reserve for publication when other accidents of a similar character occur, as they surely will. The Commissioners have asserted that "if the frame of the *Kankakee* had been the same width as that of the sleeping car, it is probable that little or no injury would have been done." With equal assurance we may say that it is more than "probable" that, if the three rear cars had been equipped with Blackstone's "horn timbers," there would have been no loss of life. If their cost is urged as a reason for not using them, the objection is not valid, so long as railroad companies can afford to append the preposterous vestibules to cars to prevent dudes and fine ladies from soiling their kid gloves in going from one car to another. The vestibules weigh and cost many times more than the "horn timbers" would, with the difference, that the principal purpose of the first is to gratify a love of ostentation in travelers and railroad officers, whereas the last would serve the blessed purpose of saving human life and preventing the most terrible suffering.

INTERNAL NAVIGATION IN FRANCE.

ATTENTION has heretofore been called to the fact that while in this country the water communications are being gradually superseded by the railroads, in Europe there has been during the last 20 years a very notable revival of interest in the waterways, natural and artificial, and the attention of Governments and engineers alike has been turned to their improvement and extension.

The United States has a system of navigable rivers and lakes unsurpassed in any country in the world, and it has at different times expended large sums in their improvement and in building canals to connect them and complete the system. Railroad competition, however, has taken away a considerable share of the business which formerly sought the Mississippi, the Missouri, the Ohio, and other rivers, and even threatens the great line of communication by the lakes and the Erie Canal, while nearly every one of the less important rivers is paralleled by a railroad line.

Our artificial waterways have actually diminished in number. The old Wabash & Erie Canal and the canal which once connected the Allegheny River and Lake Erie have disappeared; the James River & Kanawha Canal is now a railroad; the Chesapeake & Ohio, the Morris, and the Pennsylvania Canals are threatened with a like fate, while no new canals of importance have been built for years past and none are now under construction.

A notable instance of the opposite tendency in Europe is found in the exhibit made by the French Bureau of Internal Navigation at the Paris Exposition, and some account of the past and present state of the internal waterways of France may be of interest. It must be stated at the outset, that there are in that country no rivers of the size that we possess, and few that were originally navigable for vessels of any size.

It may be said that canals of any length first became possible about the beginning of the sixteenth century, when the invention of the lock was made almost simultaneously by French and Dutch engineers. The age was not favorable to the development of the idea, however, and the first canal undertaken in France was the Briare Canal, connecting the Seine and the Loire through the Loing Valley. Planned in 1604 by the engineer Hugues Cronier, under Henry IV., and his great minister, Sully, this work was not completed till 1642. It was followed by some others of small importance, but it was not until the seventeenth century that the great engineer Pierre Paul Riquet built the Canal de Languedoc, which completed a water-line from the Atlantic Ocean to the Mediterranean. Political reasons delayed the development of the system, and it was only in 1793 that the Canal du Centre, connecting the Saone and the Loire, was opened.

At the beginning of the nineteenth century there were in France about 625 miles of canals, varying widely in size and capacity, while the usefulness of these was restricted, owing to the entire lack of any works of improvement on the rivers, the navigation of which was everywhere obstructed by bars, rapids, shoals, and, above all, by the variable depth of water found at different seasons. Such works were not then in favor, and more than one prominent engineer believed with Brindley, that rivers were created chiefly to feed canals.

The condition of affairs was such that a prominent French engineer remarked that if canals had filled the gaps between the rivers, in their turn the rivers now formed gaps between the canals.

Little or nothing was done to remedy this state of affairs until after 1830, when the Government of Louis Philippe entered upon a work of improvement, which was much facilitated by the invention of the movable dam by the engineer Poirée in 1834. This made it possible to regulate the stage of water and to store up the spring floods in the rivers for use in the summer droughts. The first important works of this kind were completed in 1838, at the rapids of Bezons in the Seine, at Epineau in the Yonne and at Decizes in the Loire.

In the succeeding 10 years the development of internal navigation was rapid, the works of this period including the improvement of the Seine, the Aisne, the Saone and the Garonne, and the completion of such important canals as the Marne-Rhine, the Nantes-Brest, the Nivernais, the Berri, the Bourgogne, and the Garonne lateral.

About 1848 the railroad era was well begun, and for the next 12 years the capital contributed by Government and private enterprise was chiefly devoted to the building up of the railroad system of the country, to the neglect of its waterways.

In 1860, however, interest in the latter revived, but for the ensuing 10 years efforts were directed rather to the improvement of existing lines than to the building of new ones. In 1870 several new works of importance were undertaken, such as the canalization of the Upper Seine, the improvement of the Lot, the building of the St. Louis Canal, and finally the extensive works for the improvement of the navigation of the Rhone.

In 1878 the Government undertook to establish some uniform standard by which all internal navigation works should be governed, and at the same time laid down an extensive programme for future work. The minimum dimensions then adopted for all canals and river improvements were as follows: Depth of water, 2 meters (6.56 ft.); width of locks, 5.20 m. (17.06 ft.); length of locks, 38.50 m. (126.28 ft.); clear height under bridges, 3.70 m. (12.14 ft.). These dimensions were chosen as permitting everywhere the passage of the type of boat

most widely in use, which can carry about 300 tons of freight.

The work of carrying out this uniform system has been prosecuted diligently, as will be seen by the table below, which gives the length of waterways conforming to the Government system in 1878—the date of its adoption—and in 1887, in miles:

	1887.	1878.	Increase.
Canals	1,086	288	798
Canalized rivers	1,130	618	512
Total	2,216	906	1,310

This work required the improvement and extension of many of the older canals, but it was not permitted to interfere with the building of new canals or with the improvement of rivers heretofore untouched. Much of this kind of work has been done, so that the system of internal waterways has been considerably extended as well as brought to a uniform standard, which permits a boat conforming to the required dimensions to pass all over France.

The most difficult and important undertaking now in progress is the improvement of the Rhone, a river hard to control on account of its rapid current, its great variations in flow, and the large quantity of sand and débris which it brings down in the spring floods.

The exhibit made at Paris includes plans and drawings, models of locks and dams, and of dikes and other works, so arranged as to give not only an idea of the present means employed, but also an historical view of the work of the engineers who have controlled the internal navigation of the country.

In this connection it may be noted that the French engineers consider that the most important invention of recent years is the hydraulic lift or lock, which enables them to overcome by a single lift differences in level which formerly required several locks, and which also requires much less water, often an important consideration. Next to this is the use of the pneumatic caisson for building foundations under water, which permits them to undertake works formerly considered impossible, and greatly reduces the cost of such operations.

The great object to be sought for in the future is some method of mechanical traction to take the place of horses, and in this connection their chief hope seems to be in some form of cable towing, though it is admitted that a system which will fill all the requirements has not yet been developed.

The French engineers recognize fully the importance of the waterway in competition with the railroad, both as a carrier of heavy freights and as a regulator of rates. In this connection we cannot do better than to quote the words of M. Fleury, to whose admirable paper before the Conference on Internal Navigation at Paris we are indebted for many of the facts given above:

"Finally, it is a necessity, which continually grows more imperative, that the national industry should have the cost of transportation of its products reduced to the lowest possible point. The duty which is to-day imposed upon us, as engineers, is to secure cheap transportation by improving the existing system of internal navigation and by completing it to the fullest extent which our resources will permit; and as managers, to realize—if that be possible—such a division of traffic between the railroads and the waterways as will permit without conflict, the complete utilization of both these instruments of transportation, both alike indispensable to our prosperity."

NEW PUBLICATIONS.

Cram's Standard American Atlas of the World; Accompanied by a Complete and Simple Index of the United States: Compiled by George F. Cram. Chicago and New York; George F. Cram (price, $10.50).

An atlas is really as necessary to the intelligent man as a dictionary—that is, a good atlas—a poor one is worse than worthless. The one now under consideration belongs to the first class, and, though a first examination cannot be expected to show all the merits and defects of so large a work, it is sufficient to reveal its general quality.

From such an examination it can be said that the maps are generally clear and well printed. Those of the United States are on a large scale, so that even the small villages can be found; if they err, it is rather on the side of too great minuteness of detail, which can hardly be called a great fault. They are brought very generally up to date, from the best attainable sources of information, an important point when the map changes as rapidly as it does nowadays, and the information given appears to be from the latest accessible sources. Where a State is so large that it is necessary, in order to preserve the general scale, to divide the map into two sheets, it is always followed by a map on a smaller scale, giving the entire State on a single sheet; this may seem unnecessary, but it is really in many cases a very great convenience. A minor matter, which is also a convenience, is the printing on the margin of each map the pages on which the maps of the adjoining States or countries are to be found—cross-references which often save the time spent in turning over a number of pages, or a reference to the index.

The Index to the United States, arranged by States, gives a list of the railroads in each, and also of all the towns, villages, post-offices, and railroad stations. For the convenience of shippers and correspondents there is added a list of telegraph-offices and money-order offices, and the name of the express company doing business over each railroad line.

Including a number of statistical tables and diagrams, the atlas contains 402 pages; there are 129 separate maps of States and countries and 30 of cities. The book is well executed mechanically, and the compilation seems to have been done with great care.

Steam: by William Ripper. London and New York; Longmans, Green & Company (price, 80 cents).

The title of this book does not indicate its real character. While a portion, although a small one, is devoted to a consideration of the nature and effects of heat and the properties of steam, it is, in fact, an elementary treatise—and a very good one—on the steam-engine.

The question which a mechanical editor is called on to answer probably oftener than any other is that which comes from students, apprentices, and mechanics—"What is the best elementary book on the steam-engine?" To be compelled to say that there is no good one, seems like heaping discouragement in the path of ambition, which is, perhaps, taking its first halting steps. Happily since the admirable book of Mr. George C. V. Holmes has been written, and the one by Mr. Ripper, which we are reviewing, has appeared, a conscientious editor is no longer obliged to rate books on the steam-engine, as the lamented President Lincoln did some of the Kentucky Baptists, as being too good for destruction, but too bad for salvation. Mr. Holmes speaks of his book as an "elementary text-book," which perhaps describes it as well as any other designation could; nevertheless, parts of it are tough reading for a beginner, especially if he has had few advantages of early education. While it is an admirable book, and one whose merits are not nearly as well

known in this country as they should be, still, an easier and simpler one was needed to put into the hands of beginners. This want is admirably supplied by the book before us. The general character and scope of it will be indicated by a summary of its contents: The first three chapters are on Heat, the fourth on Combustion, the next four on the Properties and Expansion of Steam. The tenth is a general description of the Steam-Engine, which is followed by chapters on the Slide-valve and Valve-gear, Cranks and Crank-shafts, Condensers, Governors, Compound Engines, Boilers, and Practical Notes on the Care and Management of Engines and Boilers.

The descriptive matter is admirably clear, and the Author seems to have that rare faculty of understanding his subject thoroughly, and then being able to assume the mental attitude in relation to it which a person who does not understand it must occupy. He has resisted, too, the temptation which few professors seem able to withstand—that is, of showing how easy it is for them to use mathematics. The calculations in the book are either all arithmetical or else only the simplest use of algebraic notation is employed.

Less than six pages are devoted to locomotives, which seems too small a portion considering how great the interest in that class of engines ordinarily is. If that amount of space was all that was available, it would seem as though something of more interest and importance could have been given in it instead of the information that valve-spindles are of best Yorkshire iron, and the guide-bars of the best mild crucible cast-steel.

The chapter on Compound Engines is very timely, as there is now so little of an elementary character within reach of a student.

The book is well up to modern practice, and in his preface the Author says that "the rapid progress made in engineering science during recent years, and the limited space at disposal have necessitated the omission of descriptions of obsolete types of steam-engines," for which the reader may be thankful.

The engravings are made by some kind of process. They are generally fairly good, but the lettering on some of them is inferior to the other mechanical work of the book. It has 200 pages, and sells for less than a dollar. The apprentice or mechanic in a machine-shop will make a good investment of the price of the book by buying and studying it.

THE COSMIC LAW OF THERMAL REPULSION: AN ESSAY SUGGESTED BY THE PROJECTION OF A COMET'S TAIL. New York; John Wiley & Sons, No. 15 Astor Place. (Price, 75 cents.)

This somewhat enigmatical title is not made much clearer by the Preface, which is as follows:

> This essay embodies ideas the development of which has afforded the Author much pleasant mental recreation. Their consideration may not convey to other amateurs the pleasurable excitement of original pursuit; but all who are trying to unlock the mysteries of nature will find in them interesting suggestions; and it is hoped that they may excite inquiry which will lead to a substantial advance in scientific knowledge of the Constitution of Nature.

The object of the writer is, apparently, to prove that repulsion—or, rather, thermal repulsion—is of equal importance with attraction—cohesion and gravitation—as a force of nature, and in determining the present constitution of the world and the phenomena of the universe. The essay is, apparently, carefully studied and worked out, and will be worth reading by all those who, as the Author says, are fond of original investigation.

THE CITY OF ELIZABETH, N. J., ILLUSTRATED. Elizabeth, N. J.; published (under the auspices of the Board of Trade) by the *Daily Journal* Printing House.

This book is published to set forth the attractions of the city which it represents to manufacturers as a site for their establishments, and to others as a place of residence. These advantages are the long water-front; direct water outlet to the harbor of New York; nearness to and frequent communication with New York by rail; the passage through the city of two trunk lines—to which a third will soon be added—giving rail connections of the best kind, with cheap supplies of coal, iron, etc.; and, for residents, schools, churches, and other conveniences not always found in a suburban town.

The book is worthy of mention, and is distinguished from many other publications of the same kind by the notable excellence of the work done on it. The illustrations are remarkably well done, and many of them are notably good representations; the descriptive matter is good, and while it, of course, praises the city, is free from the too open puffs often met with.

The mechanical execution is very good and reflects great credit upon the publishers, showing that, in this industry at least, Elizabeth is fully up to the times.

BOOKS RECEIVED.

A MANUAL OF INSTRUCTION FOR THE ECONOMICAL MANAGEMENT OF LOCOMOTIVES, FOR LOCOMOTIVE ENGINEERS AND FIREMEN: BY GEORGE H. BAKER. Chicago; Rand, McNally & Company.

AMERICAN RAILROAD BRIDGES: BY THEODORE COOPER. New York; *Engineering News* Publishing Company. This profusely illustrated paper, reprinted from the *Transactions* of the American Society of Civil Engineers, appears in the form of a book of 60 pages, with a number of inset plates. It is received too late for full comment in the present number.

THE RETURN OF POWER IN ELECTRIC AND CABLE TRACTION. THE RAPID TRANSIT CABLE COMPANY'S CABLE TRACTION SYSTEMS FOR STREET AND ELEVATED RAILROADS: BY ANDREW BRYSON, JR. New York; published by the Author.

LOCOMOTIVE DEVELOPMENT: COMPILED BY CLEMENT E. STRETTON, C.E. Leeds, England; issued by the Associated Society of Locomotive Engineers and Firemen, as a special number of its *Monthly Journal*.

GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA, GEORGIA: ANNUAL CATALOGUE AND ANNOUNCEMENT FOR 1888–89. This School is a department of the University of Georgia, and although only organized in 1888, it has already a considerable number of students and is well equipped for its work in the several departments. The leading course is in Mechanical Engineering, but there are also courses in Geology, Physics, and Chemistry, with, of course, instruction in Mathematics, Drawing, English, etc.

TENTH ANNUAL REPORT OF THE OHIO SOCIETY OF SURVEYORS AND CIVIL ENGINEERS: BEING THE TRANSACTIONS OF THE SOCIETY AT ITS TENTH ANNUAL MEETING, HELD IN COLUMBUS, O., JANUARY 8, 9, AND 10, 1889. Columbus, O.; published for the Society.

PRATT INSTITUTE RECORD: FOUNDER'S DAY NUMBER. Brooklyn, N. Y.; published by the Pratt Institute.

ILLUSTRATED SUPPLEMENT TO THE CATALOGUE OF THE BROWN & SHARPE MANUFACTURING COMPANY. Providence, R. I.; issued by the Company.

CORNELL UNIVERSITY, COLLEGE OF AGRICULTURE: BULLETIN OF THE AGRICULTURAL EXPERIMENT STATION. Ithaca, N. Y.; published by the University.

WOOD-WORKING MACHINERY: ILLUSTRATED CATALOGUE. Philadelphia; L. Power & Company, 12–20 South Twenty-third Street.

RAILROAD SAFETY APPLIANCES, PARSONS'S PATENTS: CATA-

LOGUE AND DESCRIPTION. New York; issued by the Parsons Block, Switch & Frog Company, No. 29 Broadway.

SCREW MACHINES MADE BY THE BROWN & SHARPE MANUFACTURING COMPANY: ILLUSTRATED CATALOGUE. Providence, R. I.; issued by the Company.

ABOUT BOOKS AND PERIODICALS.

AMONG the articles in the CENTURY for December is one on the New Croton Aqueduct, which is illustrated, and gives many interesting facts in relation to that important engineering work.

In the SCHOOL OF MINES QUARTERLY for November we find articles on Maintenance of Track, by Thomas J. Brereton; on Multiple Expansion Engines, by G. Sydney Percival, and several others of much technical and special value.

The Scientific Publishing Company, of New York, announces the publication—by special permission of the British Institution of Civil Engineers—of the very valuable work on MINING ACCIDENTS AND THEIR PREVENTION, by Sir Frederick Augustus Abel, which is considered the highest authority on this important subject. In addition to the original memoir, the book will contain a compendium of the laws relating to coal-mining in the United States, Germany, and Great Britain, making it a work really indispensable to mine operators.

The electrical articles will be continued in SCRIBNER'S MAGAZINE, and in addition there will shortly be published several articles on the life of the late Captain John Ericsson. The January number gives an illustrated article on Water Storage in the West, which is timely, in view of the general interest felt in the question of irrigation. This article contains views of several of the important dams recently built in Arizona and California.

A new monthly journal has appeared in Chicago under the name of ELECTRICAL INDUSTRIES. Its object is to deal rather with the practical applications of electricity than with its scientific problems. The opening number contains a variety of in formation. It is as attractive in appearance as clear type, good paper, and excellent press-work can make it.

A new venture among the magazines is the ARENA, published in Boston. In its first number it presents discussions by high authorities of some leading issues of the day. Its object, indeed, is the discussion of moral, social, and economic questions in the most free and liberal manner possible.

In the OVERLAND MONTHLY for October James O'Meara champions the cause of the American Pacific roads against the Canadian Pacific. An article on the Supplanting of Steam, by Alvan D. Brock, is a well-considered paper on the uses of electricity in transmitting power, and the many places in which it can be applied to utilize the force of the many mountain streams of California, which are now wasted, because they are remote and generally in places where sites for mills and factories cannot be found. With electrical transmission the power of these streams can be conveyed to points where it can be used conveniently. This is a question of peculiar importance on the Pacific Coast, where coal is scarce and high in price.

In the POPULAR SCIENCE MONTHLY for December Professor Henderson continues his articles on Glass-Making. Dr. Hilber's article on the Struggle of Sea and Land is worthy of note, and there are several others of much interest. In the January number Henry J. Philpott discusses Irrigation in the Far West, giving some account of what has been done in this direction, with the effects on methods of agriculture and general conditions of the country.

The STEVENS INDICATOR for October has several interesting articles, including one on the Steam Turbine, one on Courses in Experimental Mechanics, and a note on Performance of the Steamer *Homer Ramsdell* on the Hudson River.

ENGINEERING IN THE FAR EAST.

OUR correspondent in Siam, who is engaged in engineering work in that country, sends us some interesting particulars with regard to the first railroad there. The concession for this line has been obtained from the Government and the company organized. The names of the directors chosen indicate that this is to be supported by a combination of native and foreign capital. The list of these directors is as follows: H. R. H. Krom Koon Narit; T. R. H. Krom Mun Damrong, Phra Ong Chow Warawan, Krom Mun Sammot, Krom Mun Sanprasah, Krom Mun Putaret; H. H. Prince Prisdang; H. E. Phya Samuth, H. E. Phya Nakanaisee; Messrs. Choem Sri Sriraraks, P. Gowan, J. McCarthy, H. Sigg, F. Clarke, A. J. Loftus, A. de Richlieu.

The Company is known as the Borapah Railroad Company, and the name seems to be appropriate, as we are informed that it means not only first of its kind, but also east or eastern, both names being very appropriate. The capital stock is 800,000 ticals (about $480,000), and is to be raised by local subscription. The line will extend from Bangkok, the principal city of the country, eastward to Paknam and Patriew, a distance of about 50 miles, and is to be one meter gauge. The road-bed will be constructed by local contractors, but the rails and rolling stock will be ordered from Europe, although the orders have not yet been placed.

The country along the proposed line is generally level, with no large rivers to be crossed, so that no particular engineering difficulties are presented. Stone for ballast and other purposes can be obtained in the neighborhood of the line, and there is abundance of the best timber. The country through which the road will pass is represented as very fertile. The freight will include rice and other agricultural products, teak and redwood timber. The passenger traffic is expected to be large, as the Siamese are great travelers and are very fond of using all sorts of public conveyances. The only railroad now in the country is the street railroad or tramway in Bangkok.

Concerning this road, our correspondent writes as follows: "Patriew is about 50 miles due east from Bangkok, and the line will probably be obtained without delay. The concession also touches Paknam, a possible port near the mouth of the Meinam River. While the Borapah Railroad is likely to be rather a slight affair, it surely will be much better than a wildly extravagant plunge, such as some hundreds of miles of a trunk line paralleling the river, which affords very fair transport facilities.

"It is now (October) the rainy season here, when, according to all precedents, we should have died for our temerity in being here in the great 'Jungle of the God of Fire.' We have no serious sickness, however, and the bad reputation of much of Siam results mostly from the indolent habits and dense ignorance of the people. I keep all of my men under canvas, insist on their taking the trouble to keep their beds dry, and give them a little quinine daily. The best remedy for fever is Warburg's tincture, now put up in pills also; quinine is an efficient preventive.

"It is expressive of present transport facilities away from the Meinam River that rice is worth $\frac{3}{8}$ tical ($22\frac{1}{2}$ cents) at Korat, and $2\frac{1}{2}$ ticals ($1.50) here, only 35 miles distant, with a sandy country intervening, only one hill 200 ft. high to climb, and no serious stream crossing.

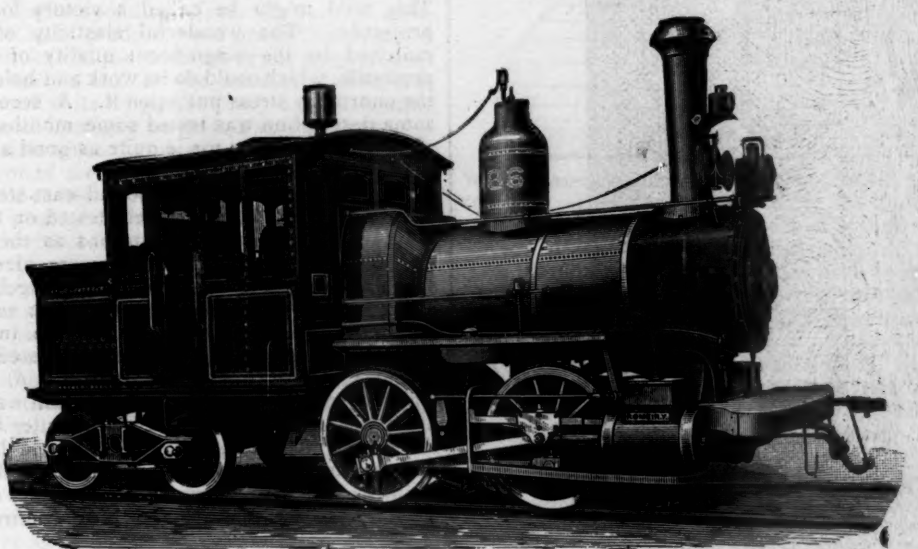
"The Governor of Korat, in answer to my inquiries, could do no more than to guess vaguely at the age of the crumbling brick wall surrounding the almost empty city. He could not, or would not, recommend three honest men as night watchmen, and declined to be responsible for the safety of any of our belongings unless we remained in the palace compound. All the business in Korat seems done outside of the walls by a few adventurous Chinamen, who deal in silk, hides, and horns for export and in cotton goods, hardware, opium, tea, etc., for local consumption. There is abundance of useful land in Siam vacant for lack of transport to market for its products."

AN ELEVATED RAILROAD LOCOMOTIVE.

THE accompanying illustration shows a locomotive constructed by the New York Locomotive Works at Rome, N. Y., for the Manhattan Elevated Railroad Company in New York City. This engine is of the Forney type, with Belpaire fire-box, and is one of a number of similar pattern employed in working the elevated railroad lines in New York City. Its general construction and arrangement will readily be seen from the engraving.

The general dimensions of this engine are as follows:

Total weight in working order	44,350 lbs.
Total weight on driving-wheels	29,700 "
Diameter of driving-wheels	3 ft. 6 in.
Diameter of main driving-axle journal	5½ "
Length of main driving-axle journal	6⅝ "
Diameter of truck-wheels	2 " 6 "
Distance between centers of driving-wheels	5 " 0 "
Distance between centers of truck-wheels	4 " 8 "
Total wheel-base of engine	16 " 0 "
Diameter of cylinders	12 "
Stroke of cylinders	16 "
Outside diameter of smallest boiler ring	3 " 6 "



LOCOMOTIVE FOR THE MANHATTAN ELEVATED RAILROAD.

BUILT BY THE NEW YORK LOCOMOTIVE WORKS, ROME, N. Y.

Length of fire-box inside	4 ft. 7 1/16 lbs.
Width of fire-box inside	3 " 7 "
Depth of fire-box, crown-sheet to top of grate	2 " 11¾ "
Number of tubes	154
Outside diameter of tubes	1⅛ in.
Length of tubes	6 ft. 3¼ "
Grate surface	16.43 sq. ft.
Heating surface, fire-box	55.77 " "
Heating surface, tubes	375.15 " "
Heating surface, total	430.92 " "
Size of steam-ports	8¾×0⅞ in.
Size of exhaust-ports	8¾×1¾ "
Throw of eccentrics	3¼ "
Greatest travel of valve	3¾ "
Outside lap of valve	0⅝ "
Smallest inside diameter of chimney	10½ "
Height, top of rail to top of chimney	12 ft. 1 "
Height, top of rail to center of boiler	5 " 5¾ "
Water capacity of tank	600 galls.

The exhaust-nozzles are single, and are carried up high; they are bored out 4 in. in diameter. The fuel used is anthracite coal, as on all the engines of this line.

The service in which these locomotives are employed is of a difficult nature, owing to the great number of stops required, and also to the sharpness of the curves, and, on some of the lines, the steepness of the grades. The trains drawn consist usually of four or five cars of the pattern in use on the elevated roads, which is lighter than that of the passenger cars employed on ordinary lines. Under all conditions these engines have done their work well, and appear to be very well adapted to the service.

THE DEVELOPMENT OF ARMOR.

BY FIRST LIEUTENANT JOSEPH M. CALIFF, THIRD U. S. ARTILLERY.

(*Continued from page 372, Volume LXIII.*)

VI.—STEEL ARMOR.

STEEL has been, almost from the first, the favorite material for armor-plates with the French, and the solid steel plate turned out by Schneider & Company at the Creusot Works is by all odds the superior of anything in the way of steel armor ever yet produced.

In the manufacture of armor at Creusot the steel is cast in cubical ingots of about 75 tons each in weight. These are worked into shape under the 100-ton hammer—seven or eight heatings and hammerings being usually required to reduce the ingots to their final shape. They are carefully annealed after the last working. After being trimmed and otherwise finished for use, they are raised to a high tempering heat, and the face for a short distance tempered in oil, and finally partially reannealed to take out the internal tempering strains, care being taken not to impair the face-hardness. These plates contain about 0.4 per cent. of carbon; one of them is shown in fig. 4. The 22-in. Schneider plate, 8 × 12 ft., weighs about 45 tons.

In the matter of steel manipulation extensive experiments have been carried on during the past year both in France and Belgium with what is known as the Evrard or lead-tempering process, the invention of a French metallurgist. The right of production under this patent has been purchased by the Chatillon & Commentry Company, one of the largest firms of metal workers of France. Under this patent molten lead is substituted for the oil or water usually employed. The metal to be tempered is immersed in the molten lead, and can be maintained at a uniform temperature throughout its entire mass. As claimed by the inventor, the molten lead, not being decomposed or vaporized by the high temperature of the casting,

absorbs the heat from its surface in a gradual and uniform manner, analogous to the abstraction of heat from the interior of the object. It is further claimed that the largest castings can be tempered in this way without warping and free from cracks, even when containing a considerable amount of carbon.

Soft cast-steel, tempered in this manner, has been experimented with in the fabrication of test armor-plates, and at a series of experiments carried on in Belgium last summer, such good results were obtained that contracts amounting to many millions of dollars are said to have been placed with the Chatillon Company for turret-armor for coast defense. Experiments with lead-tempered steel are soon to be conducted in England, and it is reported that a well-known firm of American steel manufacturers are negotiating for the right to use the Evrard process in the

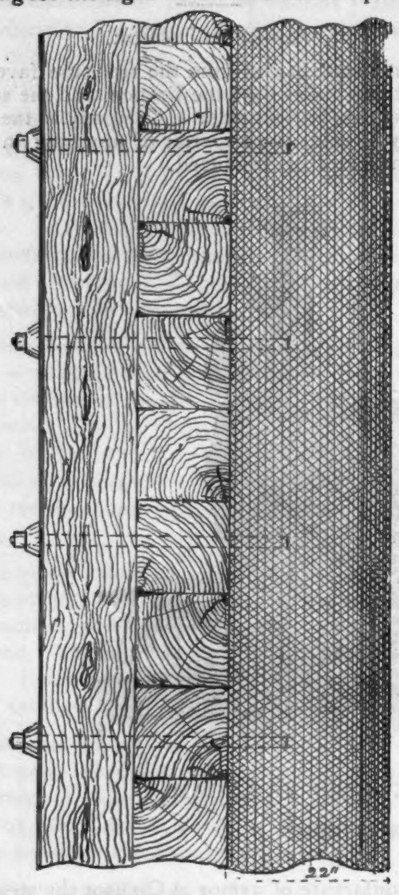


FIG. 4

United States, and that they have prepared a number of armor-plates to be sent to the French Company for tempering. Later, a part of these plates are to be tested at the factory, and the remainder are to be returned to this country for trial.

It can easily be seen that if by this process cast-steel can be successfully tempered, an immense stride has been taken in the development of steel, and for all purposes. Not only will it possess great advantage in the matter of cost over metal rolled or hammered, but it will be possible to use it in shapes that would be difficult to produce by any other method. The inventor claims that the discovery is "applicable to pieces of iron or steel of any degree of softness or hardness, rolled or forged, or simply cast, or of cast-iron, or finally of a mixed or compound nature, resulting from the association of some of the foregoing."

During a greater part of last year a series of experiments were carried on at Portsmouth, England, to test the relative merits of steel and compound armor. Of the 11 plates submitted all were of domestic manufacture, and all but two of steel. Plates of solid steel, cast-steel, unwrought, rolled, solid pressed and compound cast-steel figure in the list. The results of these experiments have been carefully guarded. It appears, however, generally speaking, that English compound are superior to English all-steel plates. There were two steel plates submitted which gave results that deserve mention—the Vicker's solid pressed and the Jessop cast-steel compound plate.

The Vicker's plate was of solid pressed steel, 6½ ft. × 8 ft. × 10½ in., and contained about 0.3 per cent. of carbon. It was attacked with two Palliser chilled and three Holtzer hardened steel 100-lbs. shot from a 6-in rifle at 10 yards' range. The calculated muzzle energy was 2,556 foot-tons. The two Palliser shot went to pieces without inflicting material damage. The first Holtzer penetrated as far as the wood backing, and was driven out again by the elasticity of the metal with force sufficient to send it back against the bulkhead through which the gun was fired. The damage to the target was confined to slight cracks around the hole made by the projectile. The second shot did not penetrate to the backing as far as could be seen, but rebounded in the same way the first had done, causing some additional cracks. The third Holtzer was sent rebounding to the front, like the other two, after making a slight penetration in the wood backing. Of the three steel projectiles, only one was seriously set up. The plate, although somewhat cracked and bulged at the rear, was, for all practical purposes of defense, as good as ever. This trial might be called a victory for both plate and projectile. The wonderful elasticity of the plate was matched by the magnificent quality of the metal of the projectile, which could do its work and hold together under the enormous stress put upon it. A second plate of the same description was tested some months later. Neither plate nor projectiles made quite as good a record as in the first instance.

The Jessop plate of compound cast-steel was, like the Vicker's plate just mentioned, tested on the *Nettle*. The plate was of the same dimensions as the Vicker's plate, and the conditions of the attack were identical in all respects. It consisted of two layers of steel; the outer one, or face of the plate, was made up of 12 separate pieces of very hard cast-steel, aggregating 3 in. in thickness; the other layer was of one solid soft cast-steel plate of 7½ in., giving a total thickness of plate of 10½ in. The advantage claimed for this peculiar construction was that, should a projectile strike one or more of the outer hardened plates, the destructive effect of the blow would be entirely local, and that no cracks would extend beyond the immediate vicinity of the point struck. The results of the trial were considered encouraging, and fully confirmed the claims of the inventor.

Whitworth, who may be called the apostle of steel in England, had been from the first an advocate of the all-steel armor-plate, and in 1887 entered the lists against both Cammel and Brown with a 9-in. plate of peculiar construction. His plate was of untempered steel reinforced by numerous screw-plugs of very hard steel inserted after it was finished. The office of the steel plugs was both to break up the projectiles and also to limit any cracks that might be developed to the space between adjacent plugs. In the experiments that followed this plate proved itself superior to either of its competitors. In another plate, subsequently submitted for trial, Whitworth carried out in another direction his theory of the subdivision of armor with the view of localizing the cracks that are pretty sure to follow the blow of a projectile against hard armor. This plate, of compressed steel, was made up in sections, each section consisting of concentric rings around a circular disk. But Whitworth was no more successful in getting a fair hearing for his armor-plate than he had been in securing a favorable verdict from the English military authorities for his ordnance, although it seems safe to say that had England followed the lead of Whitworth instead of that of Armstrong and the Woolwich people she could to-day lead the world not only in the fabrication of guns, but in armor-plate as well.

The rivalry between the compound and the all-steel plate, which began immediately after the Spezia experiments in 1876, when Schneider won his first victory for steel, still continues. England has been committed to compound armor from the first, while France has been an equally strong advocate for steel. National pride has, no doubt, had much to do in both cases with the choice. Italy

decided in favor of steel, and our own Government has, wisely we think, followed the same example.

In compound armor the office of the hard steel face is to oppose penetration and break up the projectile, while the soft iron backing holds the face up to its work, and prevents the extension of cracks through the plate. On the other hand, by far the larger half of a compound plate is of a material that offers the minimum resistance to a projectile, and a shot, once fairly through the hardened face, will have little difficulty in effecting complete perforation; in addition, the union between the steel and the iron is by no means perfect, while the backing naturally deteriorates under the rolling and reheating to which the plate is subjected.

A steel armor-plate, though possessing less hardness of face than a compound one, is more rigid throughout its mass, and offers a nearly uniform resistance through the entire thickness of plate. Schneider's first armor-plates were little more than steely iron. Subsequently the opposite extreme was reached, and, as shown in the Gavres experiments of 1880, and the Russian experiments of 1882, the opposite extreme was reached, and a plate almost as brittle as cast-iron was produced. The result of these experiments was to give a temporary set-back to the Schneider product, and a corresponding advance in favor of compound armor. In later productions a proper mean seems to have been struck, and the triumph of the steel plate at the Spezia experiments, had in the autumn of 1882, was quite as pronounced as its original victory upon the same ground in 1876, and it might be added that the result of the competitive trials since that date have been to confirm the verdict in favor of steel.

The weakness of a steel armor-plate, or of any hard armor, lies in the quality of brittleness—the inclination to crack, break up, and fall from its backing under the blows of a projectile. The desideratum in this direction seems to be a metal that, while possessing the requisite hardness, shall at the same time have the tenacity to hold together; in other words, one that shall be hard without being brittle. The solution of the difficulty would seem to lie in the direction of a mild steel that can be tempered without losing its tenacity. That this will be attained appears to be no longer doubtful.

VII.—CAST-IRON ARMOR.

The value of cast-iron as a material for armor lies in the fact of its great hardness, and when chilled this becomes so excessive as to absolutely defy any projectile yet produced. But allied to this quality of hardness is the lack of both elasticity and ductility; in other words, it is unyielding and brittle. The same objections that attend this quality in steel apply with much greater force to cast-iron. To be valuable as a material for resisting projectiles it must be used in masses so large as to preclude its employment anywhere except in permanent land fortifications, where weight and size are not important factors; and only in this rôle will it be considered.

Reference has already been made to early experiments with cast-iron, looking to its use in the manufacture of armor. No satisfactory results were obtained until Herr Grüson, a German iron-founder, brought forward his chilled cast-iron armor blocks. These have been pretty thoroughly tested, and so successfully that Grüson armor is now employed in the construction of forts by all the principal powers of continental Europe, France excepted. Herr Grüson began his experiments with chilled cast-iron many years ago, and disputes with Palliser the credit of having first invented the chilled cast-iron projectile. Today Grüson's chilled cast-iron is the only representative of this variety of armor.

The secret of Grüson's success with cast-iron is said to lie in the superior quality of his pig, in the mixing of the ores, in regulating the chill, and in the great care exercised in the casting. To this may be added the fact that the blocks or plates are cast in chill molds, which gives to the exterior of the casting a very hard surface, while the interior remains relatively soft. The peculiar shape given to the blocks adds greatly to their resisting power, the aim being to present a curved surface to the impact of a projectile. With a plate of this kind no appreciable penetration is possible. If destroyed it must be done by repeated blows delivered near the same spot.

In the manufacture of this armor an exact model of the plate to be cast is made; if of a fort, of each separate part. With the model or models thus obtained ordinary sand molds are prepared, in which are cast the chill-molds for the plates. The melted pig is drawn from the furnaces into a single receiver, and from thence fed directly to the mold, care being taken to prevent the rapid cooling of the unchilled portion of the casting. The ends of each plate are provided with a groove, and into the groove of the two adjacent plates melted zinc may be run, or iron keys inserted, when the battery is set up, thus obviating the use of bolts or any other fastenings whatever.

The general form of the Grüson plates is shown in the accompanying cut (fig. 5). They are made of various

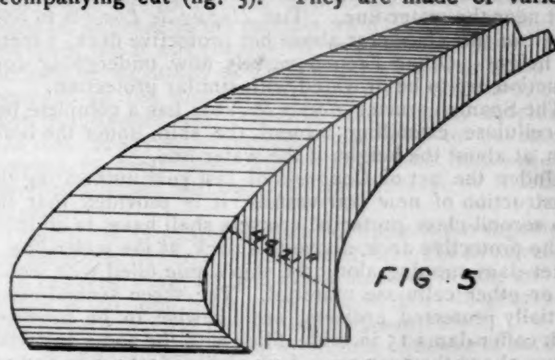


FIG 5

weights and thicknesses. The one pitted against the 100-ton gun at Spezia in July, 1886, and from which trial it came with flying colors, had a thickness of something over 49 in. at its thickest part, and weighed about 87 tons. This plate is a fac-simile of those used in the construction of the two turrets in Spezia harbor, in which are to be mounted the four 119-ton Krupp guns recently delivered to the Italian Government.

The value of any kind of armor rests, of course, upon its ability to keep out hostile shot, and conversely the value of the gun depends upon its being able to get through the armor-plate and inflict injury upon the men and material behind it.

To measure this value in the gun, the standard that has been adopted is the amount of penetration of its projectile into wrought-iron armor. In nearly all reports upon the ballistic qualities of guns will be found a statement as to the thickness of iron its shot can perforate. Knowing the diameter and weight of the shot and its striking velocity, it is not difficult to calculate the amount of penetration of any given shot. Fairbairn's formula is as follows:

$$t=\sqrt{\frac{Wv^2}{2g}}\times\frac{1}{\pi D}\times\frac{1}{K},$$

in which t represents the thickness in inches of plate perforated; W, D, and v the weight, diameter, and striking velocity in foot-seconds of the shot, and K a constant determined by experiment. Roughly estimated, a pointed projectile will penetrate as many times its own diameter into wrought-iron as it has thousand feet of striking velocity. The penetration into steel armor is from 25 to 30 per cent. less than in wrought-iron.

VIII.—WOOD ARMOR.

In addition to the armor proper of a war-ship, it is now proposed to supplement it with a belt of some material that, while offering little additional resistance to a projectile, will prevent the ingress of water following a successful blow delivered at or below the water-line. It is further proposed to apply this protection not only to armor-clads, but to vessels of a lower class unprovided with side-armor as well.

In 1886 some experiments were made in England with a substance called *woodite*—very much like porous india-rubber—which is said to be not only very elastic, but non-inflammable and unaffected by salt water. This material, in the shape of 8-in. cubes, was vulcanized on to a thin iron plate, and fired at with 3 and 6-pounder rapid-fire guns. The report goes on to say that it was difficult to

discover the points of entry, and that the protection against the influx of water was perfect. This substance has been patented in England, and has received the indorsement of some well-known authorities on naval construction. It weighs about 50 lbs. to the cubic foot, and costs £450 per ton. Its excessive cost has led to the production of a substitute which is said to weigh but about one-fifth as much as rubber, and to cost but one-tenth as much, and, while inelastic and slowly inflammable, possesses a very low absorbent power. It is proposed to pack this over the protective deck in small compartments, 18 in. deep amidships and 6 ft. deep at the sides.

The French, for this purpose, have adopted cellulose (compressed cocoanut fiber), which expands under the influence of water and prevents its inflow. This substance is to be confined in coffer-dams, and to form a complete belt near the water-line. The *Dupuy de Lôme* is to have a belt of this character above her protective deck, 1 meter in height. Other French vessels now undergoing construction are to be provided with similar protection.

The Spanish cruiser *Reina Regente* has a complete belt of cellulose extending around the ship, under the inner skin, at about the height of the water-line.

Under the act of Congress of last year authorizing the construction of new war-vessels, it is provided that the two second-class protected cruisers shall have, in addition to the protective deck, above this deck, at the water-line, a coffer-dam running along the ship's side filled with woodite or other cellulose material. The three second-class, partially protected cruisers, are likewise to be provided with coffer-dams 15 in. wide, filled with the same material, to run above the protective deck alongside the fore-and-aft bulkheads, its top to be 4 ft. above the water-line.

(TO BE CONTINUED.)

THE INTERNATIONAL RAILROAD CONGRESS.

(*Continued from page 550, Volume LXIII.*)

IN the Second Section, questions relating to motive power and rolling stock were considered. The first of these was Question VIII, on Means for Facilitating Passage of Vehicles around curves. The report was made by M. Banderali, Chief Engineer of the Northern Railroad of France.

The Congress decided that it was necessary to take into account both the track and the rolling stock in diminishing as much as possible resistance upon curves of small radius.

Track.—The superelevation of the outer rail on curves, although indispensable, should not be too great, and it is of more importance to have the rails upon curves well secured and accurately gauged; the use of transition curves in passing from the tangent to the curve is recommended, with all possible means of preventing too sudden a change of direction.

Locomotives.—The different methods employed to enable locomotives to pass easily around a curve were considered, including the allowance of longitudinal and transverse play in the journal-boxes; the use of blank tires without flanges on some of the wheels; the use of spherical bearings for the coupling rods and increased coning for the leading wheels, etc. Attention is drawn to the use of different arrangements permitting changes in the position of the axle, such as the radial journal-boxes, the Bissel truck, and especially a leading truck in the place of fixed leading wheels. The use of equalizing levers to secure proper distribution of the weight is also recommended, and finally, for causes of exceptional curvature, the use of double or twin locomotives.

Cars.—For carriages or wagons with two axles only, the use of journal-boxes admitting of considerable play is recommended. For those with three axles, the use of boxes having considerable play for all the axles, and of longitudinal play for the boxes on the center axle. For cars of unusual length, the use of trucks is recommended.

Finally, it is recommended that before the next meeting of the Congress careful experiments be made to show the resistance of cars furnished with various devises mentioned on curves of different roads.

Question IX related to Changes of Gauge and the practicability of transferring cars from one gauge to another. The report was made by M. Blancquaert, Chief Engineer of the Belgium State Railroads.

The conclusions of the Congress were that the difficulties of changing the wheels on passenger equipment were so great that they would not be counterbalanced by the convenience obtained by avoiding the transfer of passengers.

For freight cars, where the freight can be transferred cheaply, the transfer will be less costly than the change of the wheels. Where there is special freight which is difficult to transfer, it is recommended that it be carried on special crates or cars, which can be handled by cranes or other means, and transferred directly from one flat car to another. In special cases it may be possible to provide running gear especially adapted to the change.

This conclusion will seem to us in this country rather behind the times. The principal changes of gauge in Europe are at the Russian and the Spanish frontiers, the gauges adopted by those countries being different from those in use in the rest of Europe. At the Spanish frontier the amount of freight transferred is not great, but at certain points on the Russian frontier there is a great deal of heavy freight, including grain, the transfer of which must be costly.

Question X related to the Application of the Compound Principle to Locomotives. The reporter was M. Parent, Chief Engineer of the French State Railroads.

The conclusions were that, while the use of compound locomotives shows some economy in fuel, on the other hand, there is an increase in the cost of maintenance and of lubrication. It is considered, however, that further trials are desirable, and that the compound locomotive may be found useful in many places, especially where the cost of fuel is high.

Question XI related to the Applications of Electricity, and was divided into three parts: A. Lighting of Trains and Stations; B. Brakes; C. Welding of Metals, especially in repairs of rolling stock. The reporters were M. Sartiaux, Chief of Telegraph Service of the Northern Railroad of France, and M. Weissenbruch, Engineer of the Belgian Ministry of Railroads. The conclusions of the Congress were as follows:

A. Lighting of Trains and Stations.—Considering the progress made in lighting trains by electricity, the experiments already made ought to be continued. As to the lighting of stations, there is no doubt as to the advantages of the application of electricity, the only question being as to cost. It seems probable, however, that, while the first cost of an electric lighting plant may be greater, the cost of maintenance in most cases is less, considering all the advantages.

B. Brakes.—It is considered that no special progress has been made with electric brakes during the past two years, and the question whether they can be generally and practically applied is still undecided.

C. Electric Welding.—Several processes of working and welding metal by electricity have obtained a certain development, but the Congress considered that further trials were necessary, and the question was postponed until the next meeting.

The Second Section, under Question XII, adopted the following list of subjects for consideration for the next meeting of the Congress: Tires; Smoke-stacks for Locomotives; Best Utilization of Rolling Stock; Steam Production; Lubrication of Locomotives. The Congress approved this list and added one more subject, Locomotives for Yard and Station Service.

The Third Section of the Congress had under consideration the questions relating to Management, which were five in number.

Question XIII related to the Dead Weight of Trains, the report being made by M. Lefevre, Assistant Superintendent of Transportation of the Western Railroad of France.

The conclusions of the Congress were that the selection of a type of passenger carriage must depend on the nature of the traffic, and a number of circumstances peculiar to

each line. It is important to reduce the dead weight as much as possible, but in many cases the weight of carriages must be increased in order to give travellers necessary comforts. Wherever possible, however, the rates should be also increased, so that the traveller may pay for the cost of the additional weight. For freight cars no general rules can be established, in consequence of the great variation in kind of traffic and circumstances; but every possible effort should be made to reduce the proportion of dead to paying weight.

Question XIV related to the Organization of Freight Service and of Freight Trains, the reporter being M. Ronneau of the Paris, Lyons & Mediterranean Railroad.

The Congress considered that no general rules can be established under this head, the management of the freight traffic depending entirely upon the nature of the traffic, its amount and many other circumstances. The only general rule seems to be that it is best to hasten the movement of freight as much as possible, in order to secure the best utilization of the rolling stock.

Question XV related to Yard and Station Service, the reporter being M. Pichon of the Midland Railroad of France.

The only conclusion reached under this head was that, while the local circumstances and importance of stations must determine the system adopted, that of switching by gravity appears to be the most economical, wherever circumstances permit its use.

Question XVI related to the Best Arrangements for Passenger Stations where the traffic is large. The reporters were M. Cossman, of the Northern Railroad of France, and M. Goffin, of the Belgian State Railroads.

Here again the Congress declined to establish any general rules, holding that local circumstances must determine the arrangements adopted, but called attention to several large stations recently built in European cities where the arrangements seem worthy of imitation.

Question XVII related to the subjects to be considered for the next meeting. The subject chosen was Station Service, which was divided into two parts: A. The Installation of the Station, including the arrangement of yards, handling of traffic, arrangements for switching, unloading, etc. B. Station Agents and Staff. The Congress approved this question, and directed that these questions should be addressed to all the companies connected with it, and that they be requested to report the fullest particulars possible under this head.

The Fourth Section considered the questions relating to General Order, which were six in number. First of these was Question XVIII, which covered the Relations of Railroads and Navigable Waterways. The reporter was M. Colson, Engineer.

The Congress considered this subject at much length, and while recognizing the fact that in many cases the development of canals and other internal navigation was an advantage to the railroads, held that in other cases the result might be very different. It is claimed that while internal navigation in many cases receives assistance from the State, and is not burdened with taxes on the other hand, the railroads not only had to pay the expenses of management and maintenance and to pay interest on their capital, but are burdened with heavy taxes and with duties relating to postal and military service, which cause a considerable expense. The following is the declaration put forth:

"1. That these inequalities, especially those in relation to taxes, should be suppressed or, at any rate, reduced as much as possible by all measures which can be adopted by the different governments, and which may be compatible with the interest of commerce and industry.

"2. Especially where it can be avoided hereafter, no new waterways should be opened in districts where the railroads can sufficiently serve the traffic."

Question XIX related to the Means of Improving International Relations with regard to the Transportation of Passengers and Baggage. The reporter was M. De Perl, of the Grand Russian Railroad Company.

The Congress recommended a general treaty to cover the subject of the passenger and baggage service, and also expressed the opinion that arrangements should be made to facilitate as much as possible the examination of baggage at frontier custom houses.

Question XX related to Premiums to Employés for Economy in Expenditures and for Increase of Receipts. The reporter was M. Ambrozovics of the Hungarian Railroads. This question was discussed at some length, and, in the opinion of the Congress, presented many difficulties. It was considered that premiums for economy in expenditures—as of expense for fuel, oil, etc., on locomotives—were desirable, as bringing into play the personal interest of the employé in improving the results of working. As to premiums and commissions for increase of business, the case was much more difficult, and the Congress did not approve of the idea of premiums based on increase of gross receipts, on account of the great difficulty of determining exactly the agents causing such an increase. Premiums based on increase in net receipts would be less difficult to establish, but it was considered profitable to adopt here the form of a gratuity or dividend, the amount to be determined by the directors, and the division to be decided upon in the same way. In brief, the general conclusion was that the system of premium was only to be recommended in those cases where they could be based on a specified amount, and not upon any general or indefinite increase.

Question XXI related to Relief or Benefit Arrangements for Employés. The reporter was M. Georges de Laveleye. The answers were divided into numerous heads, and the report is too long to be given here in full. In general, it may be said that the recommendations included:

1. A careful organization of the management of such institutions.

2. The collection of full statistics in relation to age, period of service, conduct in service, promotion, condition of life (whether married or single), mortality in different departments of the service, and many other points in relation to the physical, mental and moral condition of employés.

In relation to relief funds, it was considered very desirable to secure all possible statistics with regard to the nature and amount of the help given, the amount contributed by the employés to the company, and the percentage of wages necessary to maintain such relief bureaus.

Attention was also called to the advantages which had been secured on some roads, especially in Russia, by the establishment of lending banks or bureaus for making loans to employés in cases of necessity, and to arrangements for providing dwellings for employés.

Co-operative societies for purchasing household supplies, provisions, etc., had also been found to work well in many cases.

It is especially considered that the organization of schools for apprentices and for the instruction of candidates for the railroad service is to be desired wherever it is possible.

Question XXII related to the Composition of Passenger Trains, with special reference to the number of classes. The reporter was Mr. Findlay, Manager of the London & Northwestern Railroads.

The conclusions were, in the first place, that in making up express trains it would be well to include third-class carriages, admitting wherever possible this class of travellers to the advantages of the express trains. This can be done without great increase of cost from the fact that in the third-class cars the dead weight per traveller is generally much less than in those provided in the first and second-class passengers. It is especially desirable that this be done in trains running long distances. It is objected to this that the introduction of third-class carriages in fast express trains would so increase the length of those trains that the speed must be reduced; but where the traffic is large, it is worth while to consider whether it would not be best to introduce a class of express trains principally for such travellers, and which would be intermediate between the fast express and the accommodation trains. The decision of this question must depend upon the amount and nature of the traffic. In many cases it may be of advantage to introduce a fourth class, as is done on the German and some other roads, but the decision of this point must depend upon local circumstances.

Question XXIII related to the subjects for the next meet-

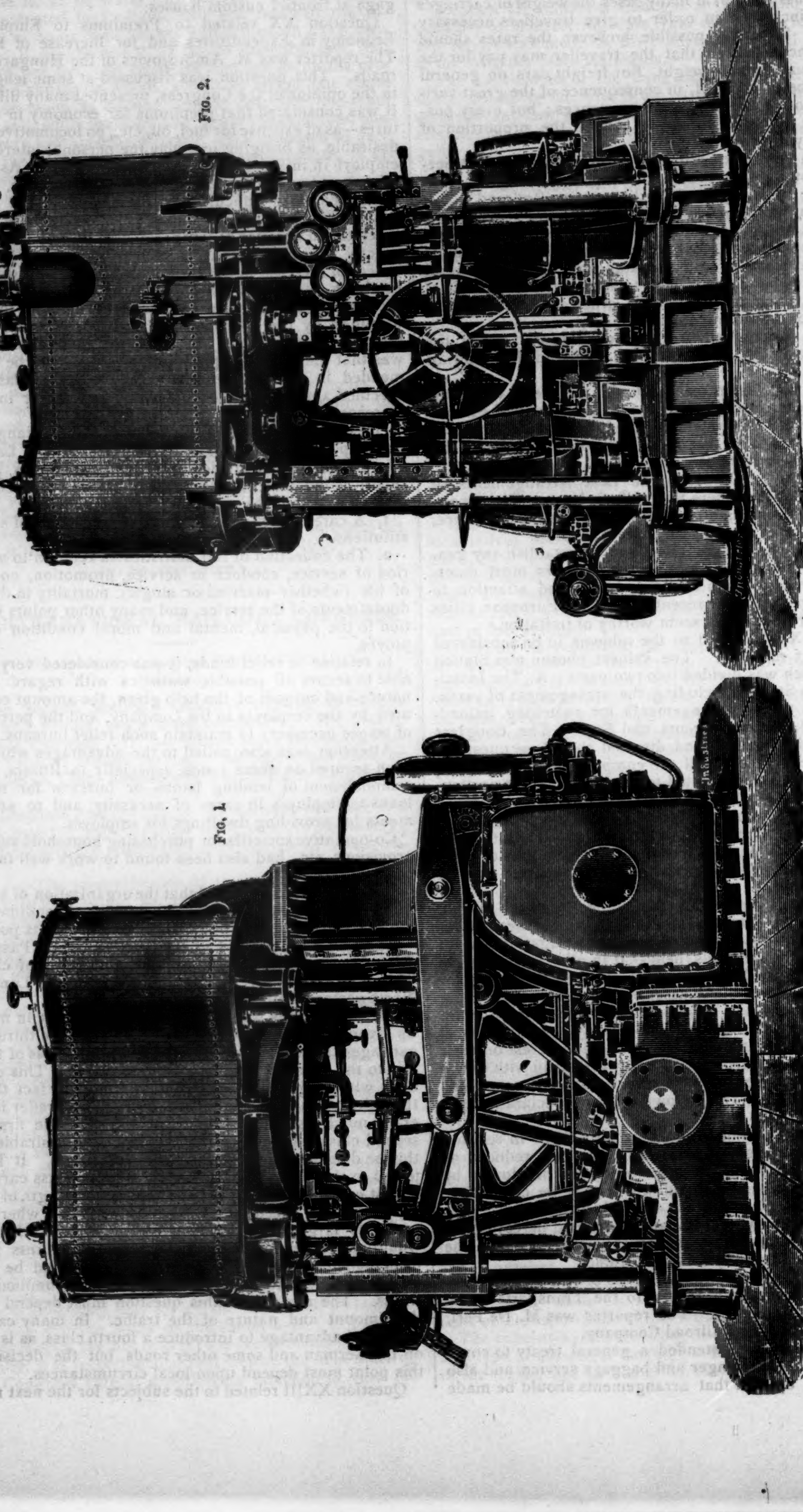


Fig. 2.

Fig. 1.

QUADRUPLE-EXPANSION MARINE ENGINE.

ing, and those recommended were: Conventional Value of the Different Units of Transportation; Price or Rate per Unit of Transportation, and Coefficient of Management—Classification of Receipts and of Expenses. These were approved by the Congress.

The Fifth Section considered questions relating to the management of secondary or branch railroads. These were four in number. The first, Question XXIV, related to Freight Cars for Secondary Roads. The conclusions reached were that on secondary or light roads the freight cars should be able to carry loads as great as those on the main lines, but that the weight per axle should not exceed that allowed for locomotives.

Question XXV related to Motive Power, and was divided into two sections:

A. Motors other than locomotives—electric, compressed, air, gas, cable, etc.

B. Systems for railroads of heavy grade. The conclusions laid down by the Congress were as follows:

1. The systems of electric accumulators or storage batteries can be used on lines of light grade, but so far have not proved themselves to be sufficient where the trains are heavy or grades are steep.

2. Electric motors with currents conveyed either by overhead or conduit systems can be applied in many places, as in cities, in long tunnels, etc., where the use of locomotives presents inconveniences. Compressed air and hot-water motors can be substituted for locomotives in the same conditions where the runs are not too long.

4. Steam carriages or cars in which the motor is carried in or combined with the car can be used on lines where the traffic is very light, without regard to their length.

5. The rack-rail system can be usefully applied on lines with very heavy grades, and is to be recommended both on account of first cost and cost of operation.

6. The cable system is only applicable for short distances, and is chiefly to be recommended where water-power can be used.

Question XXVI related to the Transfer of Freight between Lines of Different Gauges.

The conclusions were that special installations for transfer trucks, etc., were only warranted where the traffic was large, but in most cases the cost of transferring freight would not be a serious obstacle to the development of secondary lines, which were really needed by the sections they were built to serve.

Question XXVII related to systems of management of secondary roads, whether their operation should be by the company owning them directly, or by contract. This question would, of course, have to be determined entirely by local circumstances.

Question XXVIII related to the Building of Railroads or Steam Tramways upon Public Roads. This was considered advisable in many cases, as, for instance, in connecting neighboring villages, connecting towns with main lines of railroad and similar cases. In all these cases it is considered that the road should conform as nearly as possible to the ordinary tramway or street railroad, using the grooved rail, and arranging the tracks so as to interfere as little as possible with the ordinary traffic of the highway. The only additions to the ordinary tramway would be the necessity of more careful watching of the road in order to prevent accidents.

This concluded the formal proceedings of the Congress, with the exception of the closing session—which was principally devoted to complimentary speeches—and of the banquet and reception tendered the members by the Government and the city of Paris.

It will be seen that, while a wide range of questions was considered, the really definite conclusions reached were few in number. This was to be expected from the nature of the Congress, as has been remarked before, and it may be said that it accomplished quite as much as might have been expected. Many important subjects are left to be considered at the next meeting, and it is to be hoped that the statistics which are to be collected during the two years before its meeting will be of a nature to throw light upon the disputed points, and to present valuable information for the use of engineers and for railroad managers.

QUADRUPLE-EXPANSION ENGINES.

(From *Industries.*)

THE accompanying illustrations show a set of quadruple-expansion engines built at the Phœnix Works, Paisley, Scotland, by Messrs. Fleming & Ferguson. Fig. 1 is an end view of the engine; fig. 2, a front view; fig. 3, a detail view of the valve gear; fig. 4 a cross-section of the vessel showing the position of the engines in the ship. This engine has been heretofore illustrated, but the present description is fuller, and the illustrations now given show interesting details of the valve gear, etc., not before given.

As will be seen from figs. 1 and 2, although there are only two cranks, all the four cylinders, respectively 24 in., 30 in., 40 in., and 60 in. in diameter, are placed on the same level and work in pairs. The position of the cylinders is as follows: On the starboard side at the forward end of the engine-room is the high-pressure cylinder; the main steam pipe, 7 in. in diameter, running in a line parallel with the center of the vessel from the boiler to the piston-valve is placed between the high-pressure and intermediate high-pressure cylinder, which is also on the starboard side of the center line. The other two cylinders, with a second piston-valve, are placed on the port side. The cylinders are supported by two cast-iron columns on the condenser and two wrought-iron columns on the bedplate. The cylinders and valve casings have independent covers, permitting of ready access for overhauling. The connecting rods are steel castings of a triangular pattern, each taking a piston rod at the upper angles, while the apex is attached to the crank. To assist the connecting rods when turning the top and bottom centers, as well as to actuate the air, circulating, main bilge, and feed pumps, levers are fixed to both connecting rods. Although the stroke of the cranks is only 36 in., the actual stroke of the pistons is, owing to the oblique action of the connecting rods, 42 in., the levers being proportioned to reduce the stroke of the pumps to 18 in. In large engines, two sets of air and circulating pumps are fitted, but in the *Singapore* there is only one set, worked off the after engine, the air-pump being 21 in. in diameter, the circulating pump, which is double-acting, 11½ in. diameter. The two feed-pumps are 3¼ in. diameter, and the two bilge pumps 3¼ in. diameter, all with 18 in. stroke. The tails of the forward levers are utilized for working the auxiliary pumps for sanitary

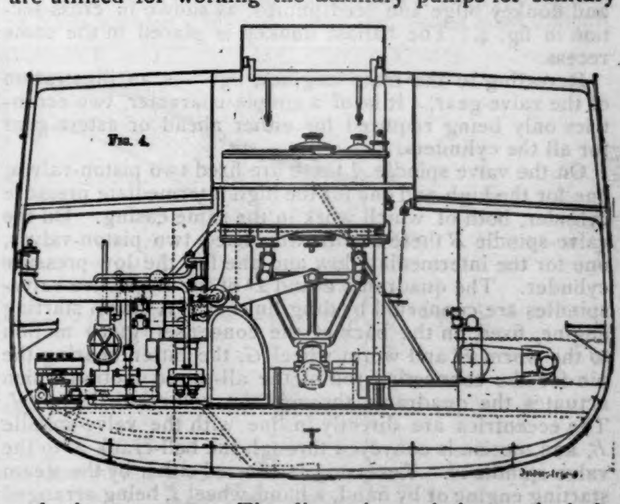


FIG. 4.

and other purposes. The dimensions of the crank-shaft, piston-rods, etc., are the same in proportion to the size of cylinders as they would be in any other quadruple engine built under the survey of Lloyd's Register, but, owing to the arrangement of triangular connecting rods, there is a better division of power in actuating the crank-shaft as compared with engines of the ordinary type, while greater compactness is secured without sacrificing accessibility. The arrangement of covers to the valves on the upper part of the engine facilitates their removal, while the position of the valve casings between the cylinders economizes space and insures shorter steam passages.

The fore-and-aft space occupied is considerably less than would be required for a triple-expansion engine of 1,600 H. P., which is the power of this engine. Fig. 4 is a cross-section through the engine-room. The boiler, constructed of Siemens-Martin steel, is of the ordinary multitubular type, 14 ft. 6 in. diameter, 18 ft. in length, and having three furnaces at each end. It was tested to 330 lbs. by hydraulic pressure, and works at 165 lbs. per square inch. In a recess on the starboard side of the forward stoke-hole is the auxiliary or donkey boiler, for sup-

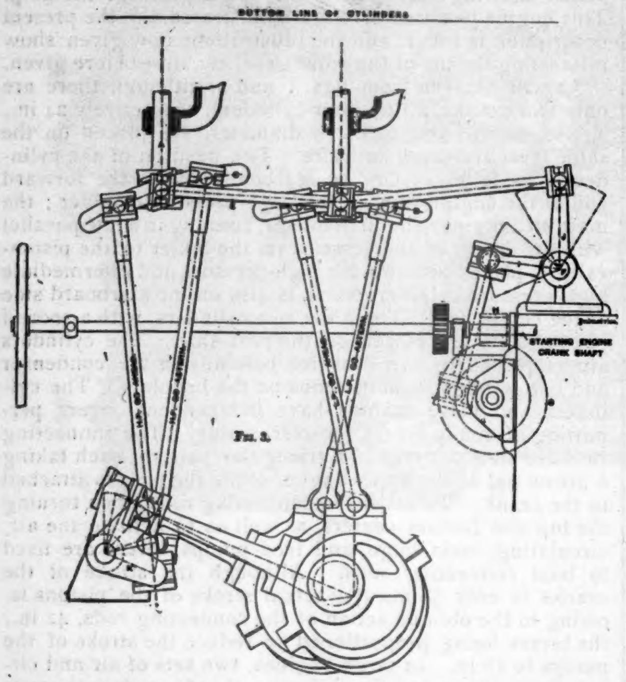


FIG. 3.

plying steam to the steering-gear, winches, etc.; and a similar recess off the coal bunkers, at the after end of the engine-room, is appropriated to a store-room, oil tanks, and the steam dynamo required for lighting the vessel. On the port side of the engine-room, a large recess is devoted to the usual sea connections, bilge suction boxes, and donkey bilge and feed-pumps, as shown in cross-section in fig. 4. The ballast donkey is placed in the same recess.

Reverting to the main engines, fig. 3 is an illustration of the valve-gear. It is of a simple character, two eccentrics only being required for either ahead or astern gear for all the cylinders.

On the valve spindle *A* there are fixed two piston-valves, one for the high and one for the high intermediate pressure cylinder, both of which work in the same casing. On the valve-spindle *B* there are likewise fixed two piston-valves, one for the intermediate low and one for the low-pressure cylinder. The quadrants *C* and *D* of the respective valve-spindles are connected by drag links *E*. A steam starting engine, fixed on the back of the condenser, gives motion to the worm *H* and worm-wheel *G*, the latter bearing the pin for the connecting-rod of the all-round motion which actuates the quadrants through the bell-crank lever *I J*. The eccentrics are directly in line with the valve-spindle *B*, and motion is conveyed through the bell-crank *K* to the valve-spindle *A*. Reversing is effected either by the steam starting engine or by hand, a hand-wheel *L* being arranged on the outer end of the crank shaft of the starting engine, and should either of the forward cylinders or the forward crank be disabled, the engines can be readily disconnected, and the after engine worked as an ordinary compound.

The fuel consumption, both on the trial trip and in regular work, recorded in vessels fitted with this type of engine is very satisfactory. On the steam trial of the *Singapore*, which was conducted under the supervision of Mr. James Mollison, Chief Engineer Surveyor to Lloyd's Register at Glasgow, the consumption of coal was found to be only 1.121 lbs. per H. P. per hour, the engines running at 80 revolutions and exerting fully 1,600 H. P. The vessel thus attained a mean speed of 12¾ knots on the measured mile in Wemyss Bay. The *Singapore* is intended for local trade between Singapore and neighboring ports, and carries 1,500 tons dead-weight on 13 ft. draft of water. Accommodation is also provided for a certain number of passengers.

THE PARIS METROPOLITAN RAILROAD.

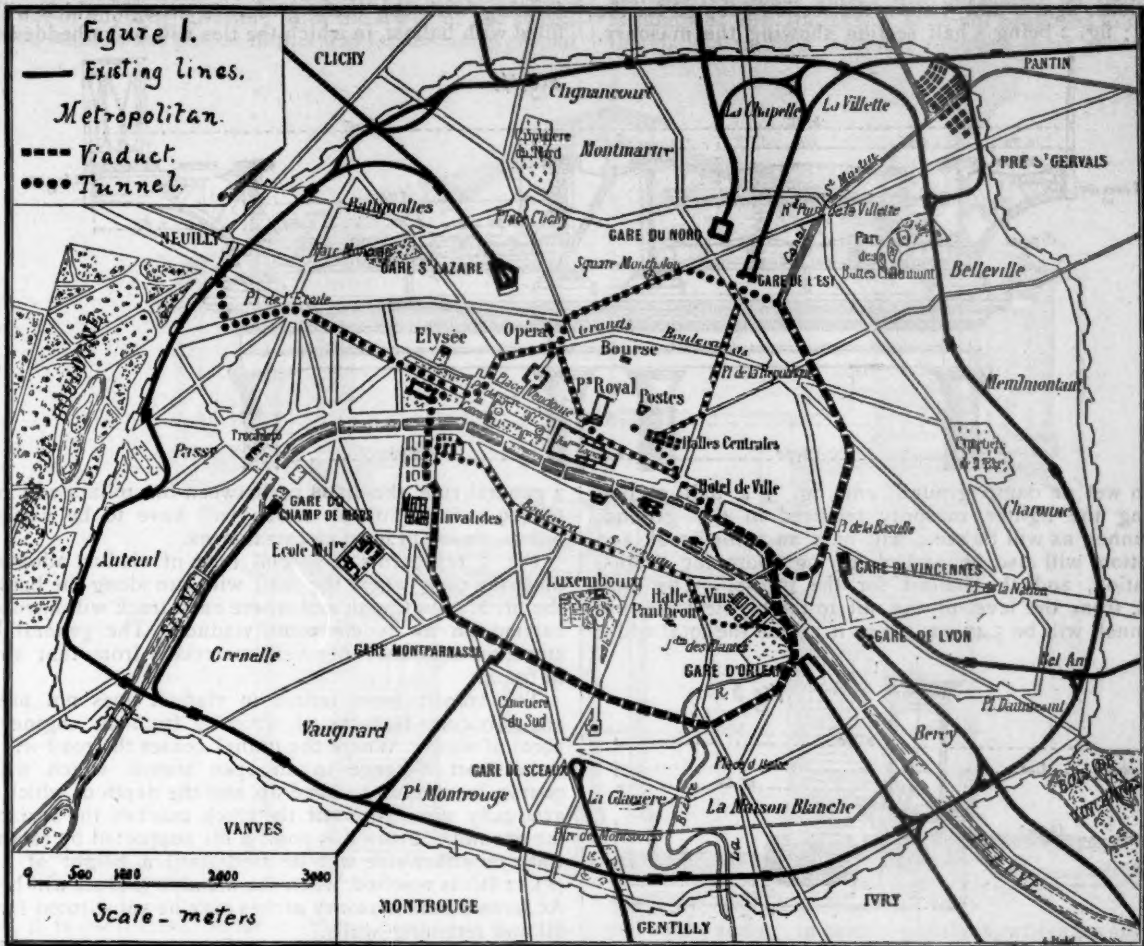
FOR some time past there has been an active discussion concerning the Metropolitan Line, which is urgently demanded by the necessities of passenger travel in the city of Paris. There is already in existence a Belt Line surrounding the city, connecting all of the railroads which enter it, but that is on the extreme outskirts of the city, and too remote from the center to be of any assistance in solving the problem. This is, as in most other large cities, very much complicated by the questions arising as to cost, right of way, and injury to existing property. A number of plans have been proposed, and the latest (which apparently meets with approval) is that of M. Le Chatelier, a noted engineer, of which we present a general description with some illustrations; the latter taken from *Le Genie Civil.*

In preparing this plan reference was had to the experience already gained with steam or rapid-transit lines in London, New York, and Berlin. It must be remembered, however, that in Paris the conditions are essentially different from those of the other cities. In New York, owing to the peculiar shape of the city, the lines run in one direction only. In London—as is the case in New York also—special attention has to be paid to a great rush of traffic in certain hours of the day to and from the business quarters of the city, and the main object of the lines is to connect those quarters with the outer districts occupied for residence purposes. In Paris this special movement has practically no existence, and the traffic is much more evenly divided, not only through the different portions of the day, but in the different directions. In Berlin the City Railroad was located and built mainly with a view to military or strategic considerations, the public convenience being entirely secondary. In Paris these conditions are met by the Belt Line, and the Metropolitan Line is intended altogether for public accommodation.

The accompanying map shows a general view of the city, the heavy black lines showing the existing roads, including the Belt Line, and the various lines entering the city, with the location of their stations. The dotted lines show the proposed Metropolitan Road, which may be said roughly to consist of an irregular circle, with three cross lines and an arm or spur connecting with the outer Belt Road. Of the Metropolitan Road about one-half, in the southwestern part of the city, will be a viaduct or elevated road, and the remaining half, in the northwestern part of the city, will be generally in tunnel. These lines, it is thought, will provide for the circulation of traffic in both directions from east to west and from north to south. The lines have been so located as to reduce as far as possible the cost for land and right of way, and to use wherever practicable the public streets, without interfering with the ordinary traffic upon them. Other branches may be added to this system hereafter, as the needs of the city may require. Under this plan, the total length of the lines to be constructed is 23.153 km. (14.387 miles), of which 11.610 km. (7.214 miles), or a little more than one-half, will be above ground, and the remainder in tunnel.

Of the total length of line, 30 per cent. will be level; 41 per cent. with grades less than 1 per cent.; 15 per cent. will have grades between 1 and 2 per cent., and the remainder, or 14 per cent. of the total length, will have grades between 2 and 2.5 per cent. Where stations are located upon a grade, the maximum grade passing the station will be in all cases reduced to 0.5 per cent. Again, of the total length of the line, 70 per cent. will be tangent; 5 per cent. will be in curves of over 200 m. (656 ft.) radius; 5 per cent. in curves of 200 m., and 20 per cent. in curves of 150 m. (492 ft.) radius. The number of stations provided for is 27, the average distance between them being 857 m. (2,811 ft.), while the shortest interval between two

adjoining stations is 425 m. (1,394 ft.). It would seem, with our New York experience, that the number of stations is rather small, and the interval between them somewhat



greater than it should be to accommodate properly the travel.

Fig. 1 is a general map, showing the principal points in the city, and the lines which are to be constructed.

Fig. 2.

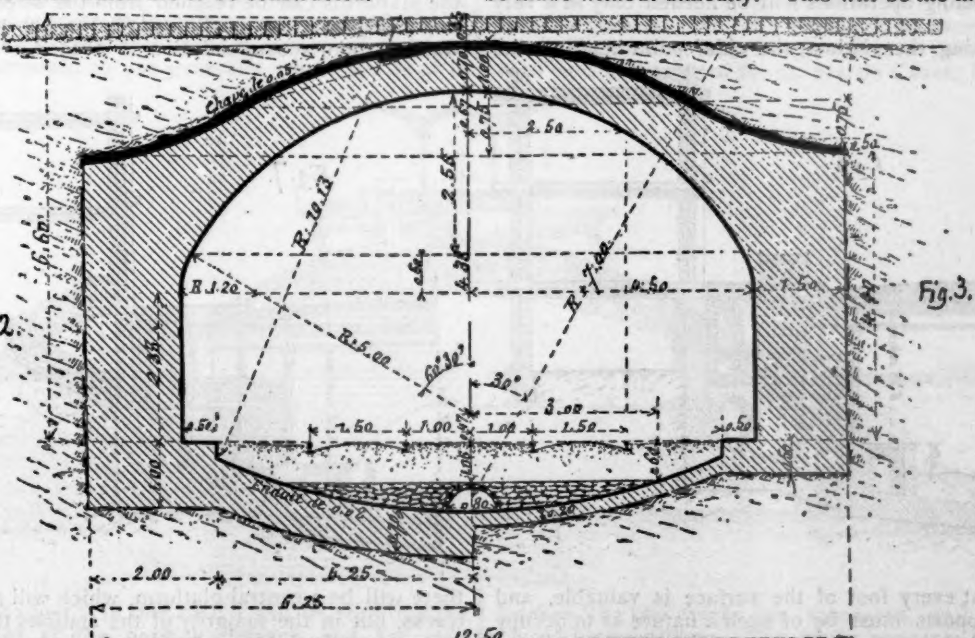


Fig. 3.

The construction of the underground section will be somewhat difficult in consequence of the necessity of avoiding the sewers and other underground conduits, which exist in great number. Especially is this the case where the road must cross the great collecting sewers which run on either side of the Seine. The solution adopted is to divert the sewers from their present line wherever they interfere with the railroad, and to build a new sewer until a point is reached where the crossing can be made without difficulty. This will be the most difficult part of the work, as the construction of the tunnel itself will nowhere present any great difficulties, and it will not be at any point very far below the surface.

The plan adopted for the road may be divided into three separate types: The underground, the viaduct, and the transit from tunnel to viaduct. In the accompanying illustrations, figs. 2 and 3 show the section adopted for the tunnel; fig. 2 being a half section showing the masonry,

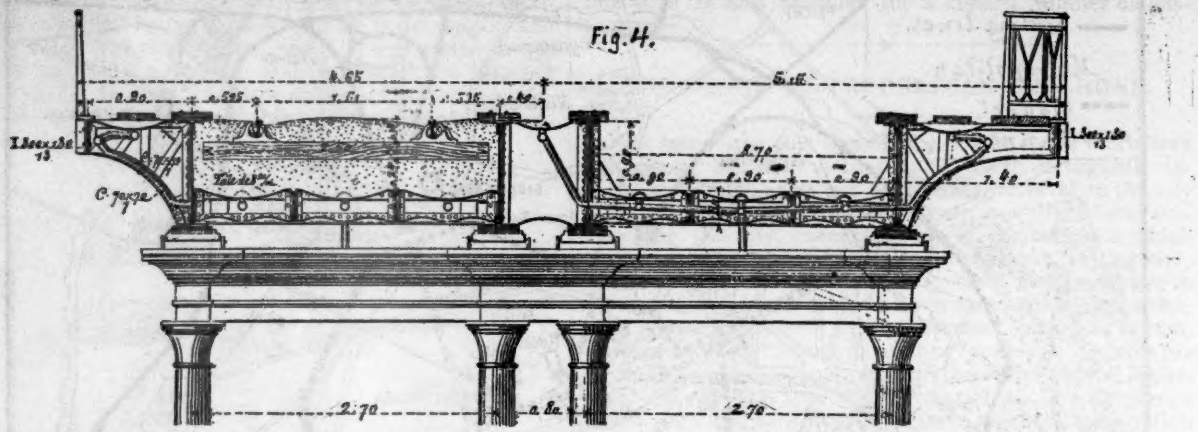


Fig. 4.

etc., in wet or damp ground, and fig. 3 a half section showing the lighter masonry required in dry ground. The tunnel, as will be seen, will have an arched roof, and the bottom will also be arched, giving room for drains, foundation, and the ballast for the tracks. The total height, from the level of the rail to the hightest point of the tunnel, will be 5.47 m. (17.94 ft.), and the total width

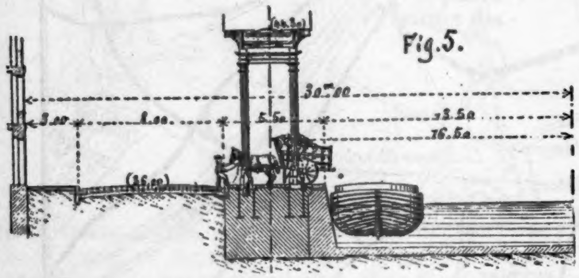


Fig. 5.

10 m. (32.8 ft.). The tracks will be double and of the normal gauge. In general the tunnel could be built by making an open cut, constructing the masonry, then filling up over the masonry and restoring the street pavement. Actual tunneling operations will be needed only in a very few places.

In designing the viaduct, the chief point kept in mind

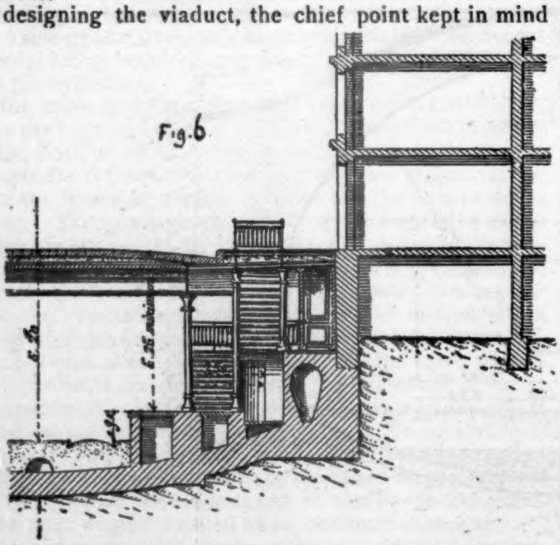


Fig. 6

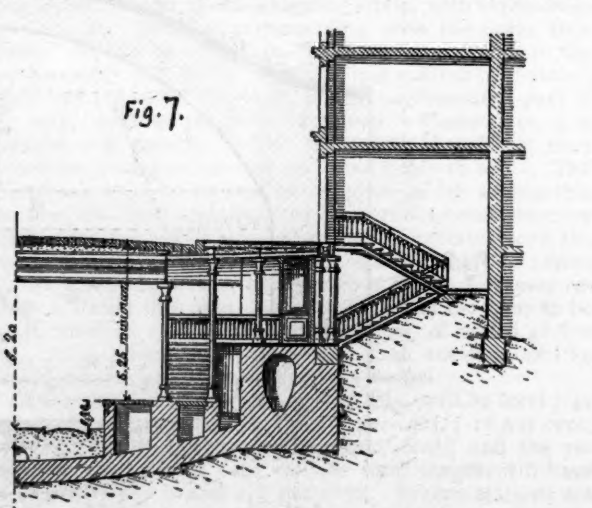


Fig. 7.

has been that every foot of the surface is valuable, and that the supports must be of such a nature as to occupy the least possible space. The general plan adopted for this viaduct is shown in fig. 4. It consists of four girders placed in pairs, each pair carrying one of the tracks; the dimensions are shown on the drawing, in meters.

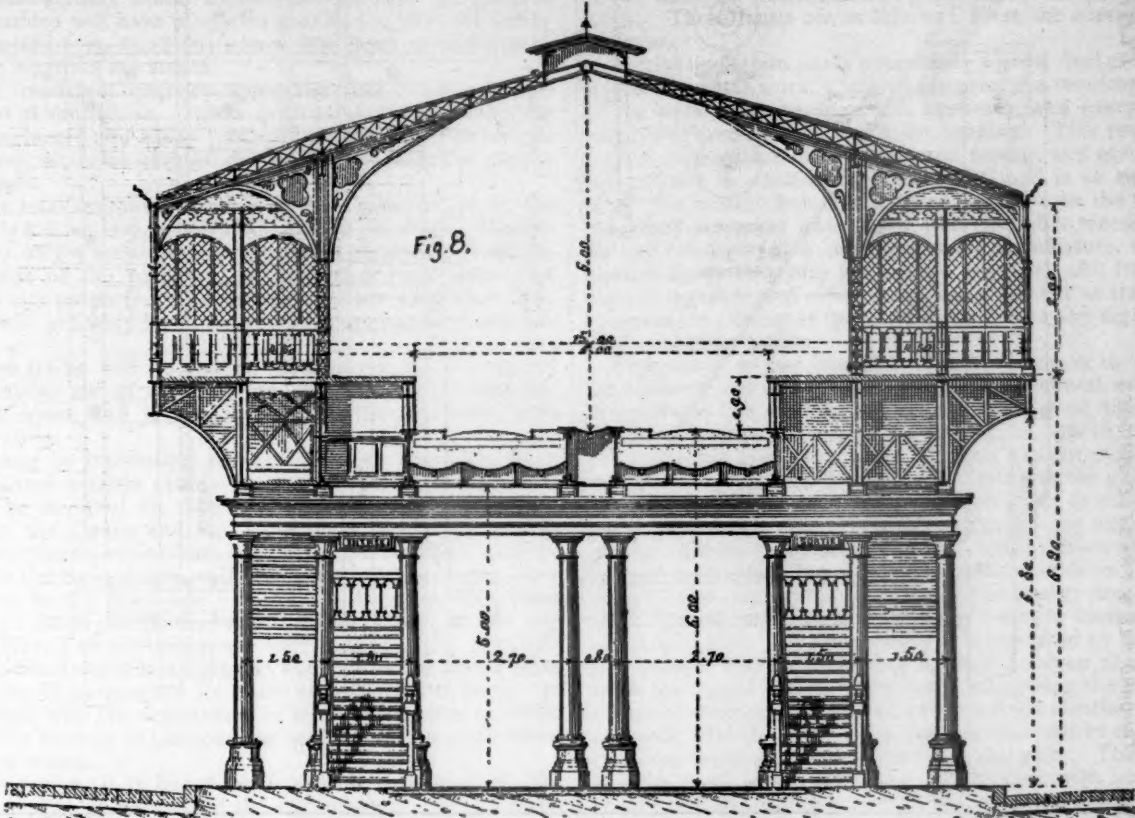
In order to reduce the noise as much as possible, it is proposed to make the roadway as shown in fig. 4—that is, to carry it on cross-girders supporting a sheet-iron floor, forming with the main girders a trough, which will be filled with ballast, in which the ties will be embedded. As a general rule, the distance between the pillars will be 15 m. (49.20 ft.); this, of course, will have to be varied at points, owing to local circumstances.

Fig. 5 represents a special form of viaduct adopted to meet the case where the road will run along the banks of the St. Martin Canal, and where each track will have to be carried on an independent viaduct. The general construction does not differ very materially from that shown in fig. 4.

The transit from tunnel to viaduct does not present any particular features of difficulty from an engineering point of view. Where the tunnel ceases the road will run for a short distance in an open trench, which will, of course, be carefully walled up, and the depth of which will gradually diminish until the track reaches the surface of the ground. From this point a fill supported by retaining walls on either side will be used until a height of 4 m. (13.12 ft.) is reached, when the metallic viaduct will begin. At some points masonry arches may be substituted for the fill and retaining walls.

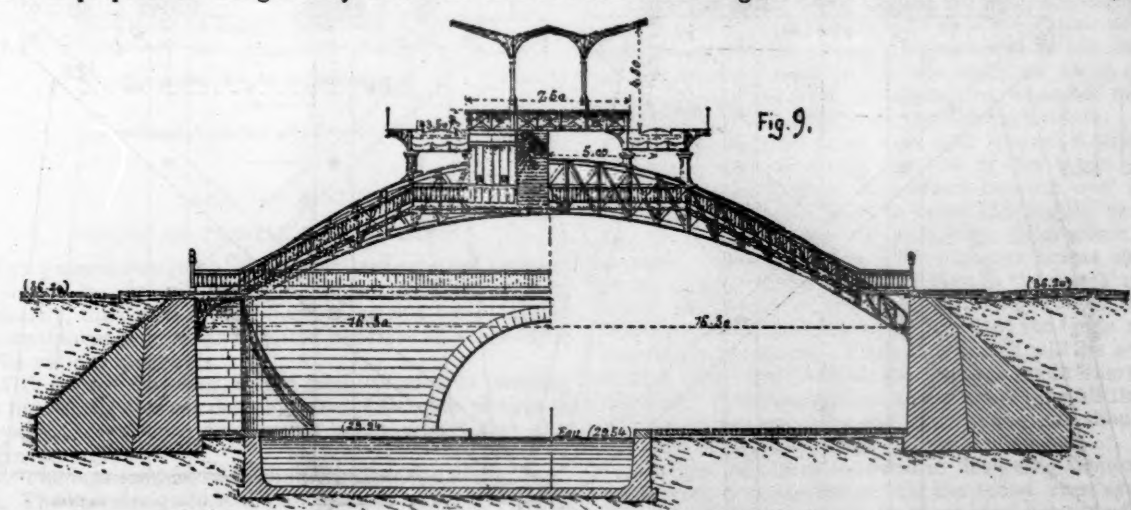
The stations, as there is no baggage or freight traffic to be provided for, present a comparatively simple problem. They will consist in general simply of platforms, from which access can be had to the cars, and of steps by which the platforms can be reached from the street. As the interval between trains will usually be short, little or no waiting-room accommodation is needed. In some cases there will be a central platform, which will serve for both tracks, but in the majority of the stations there will be a separate platform for each track, and the tracks will be kept at the regular distance apart. Figs. 6 and 7 show half sections of the stations where the road is underground, fig. 6 showing a staircase running directly from the side-

walk, while in fig. 7 the entrance is in the building at the side of the street, the stairs being in the building or underneath the sidewalk. The latter type is preferred, as it will not in any way interfere with the traffic of the street. Where stations are placed in this way for the underground are provided, one on each side of the road, and separate staircases. In both the subterranean and the overhead stations the ticket offices will be placed on one of the landings of the staircase. It is not proposed to make all the viaduct stations uniform, although their general plan



road, it is considered better to change somewhat the construction of the road; and, instead of widening the tunnel, to make an open cutting and carry the street over it upon iron girders. This will be done, because the span, including the platform and space for access, would be too great for a masonry arch, except in one or two places where the road is some 30 ft. below the street level.

Fig. 8 shows a cross-section of a station of the type which it is proposed to use generally where the road is will be the same. In certain positions, where the surroundings seem to require it, there will be more ornamentation and some attempt at architectural display, but it is not considered that in a narrow street there are opportunities for this, as there will be in more prominent positions, as in the Rue de Rivoli or the Avenue de l'Opera. Fig. 9 shows a plan adopted for a station in an exceptional position. This station is to be placed at a point where the road runs alongside of the St. Martin Canal. Here, as will



carried on a viaduct. In this case it will be seen that the tracks continue at the normal distance, and the only change made is in lengthening the cross-girders on which the structure is carried, and putting under them additional columns to support the stations. The stations will be constructed almost entirely of iron. Separate platforms be seen, the two tracks are separated, and a platform placed between them. The whole structure is carried by arched girders, resting on abutments on either side, spanning the canal and the adjoining quay. At either side of the station, adjoining the canal, the tracks are separated one on each side of the canal, carried on rows of pillars,

PLATE 69

"DENVER & RIO GRANDE RY.
STANDARD PILE & TRESTLE BRIDGES

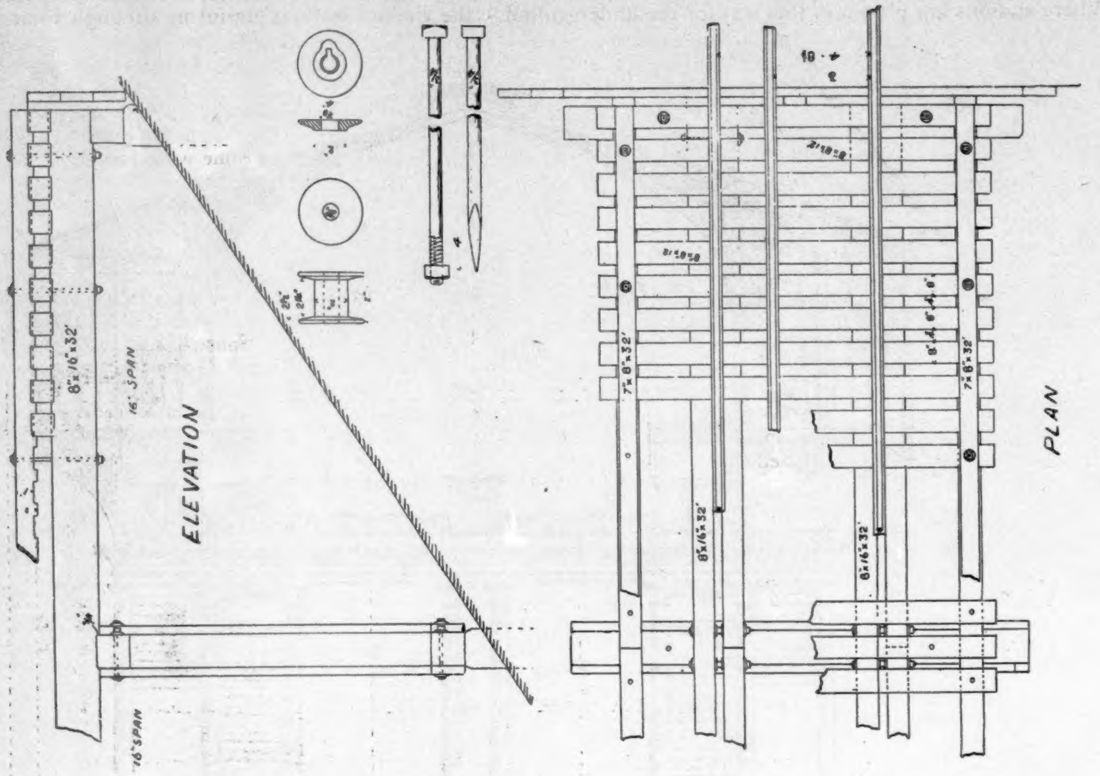
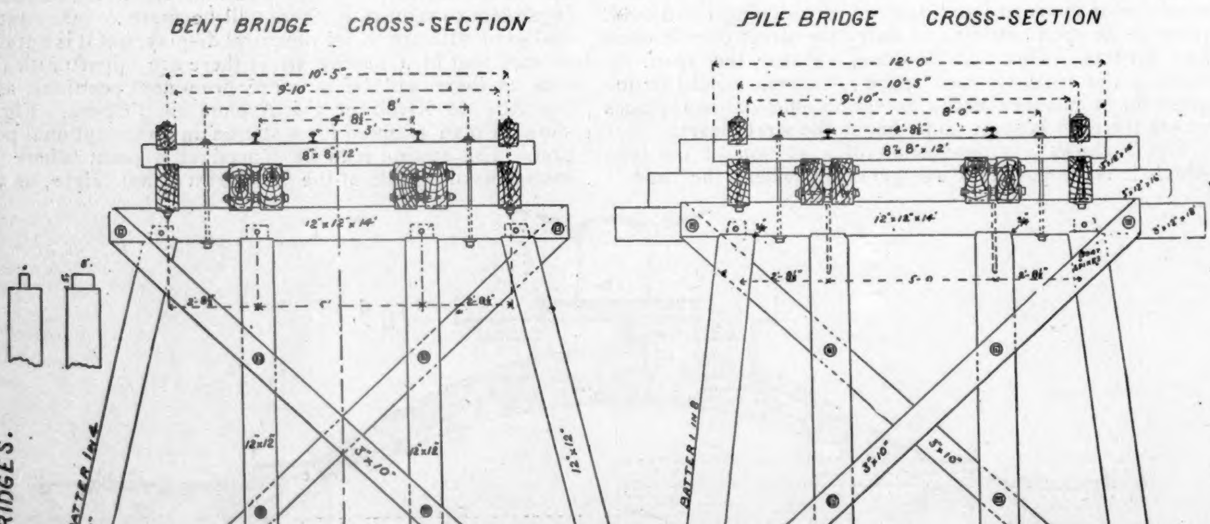


PLATE 68

"DENVER & RIO GRANDE" RY.
STANDARD PILE & TRESTLE BRIDGES.



as shown in fig. 5. As before noted, however, the system of separate platforms is considered preferable, and a single platform between the tracks will be adopted only in exceptional cases, as in that shown in fig. 9. In this case the stairways giving access to the platform are carried by the cross-girders which support the station. In general the stations will have platforms 4.50 m. (14.76 ft.) in width, and raised 1 m. (3.28 ft.) above the level of the track. Their length is not stated.

An important question where the road is underground is that of ventilation. It has been carefully considered by the engineers and a plan proposed for artificial ventilation, the foul air to be pumped out by engines placed at proper intervals.

The total estimated expense of the construction of the road is $28,000,000, or about $2,000,000 per mile. This includes only a small sum for purchase of private property, as most of the road will be built upon public streets or other city property. The estimate seems somewhat low, and will probably be increased on more careful examination.

The trains will be run by locomotives, but the type of locomotive and of car to be adopted has not yet been decided upon, and is not included in the plan under consideration.

It may be interesting to note that the engineers have submitted a table estimating the number of trains which will be required on different sections of the road. Between the Opera and the Place de la Bastile, by way of the northern circuit, from 8 to 20 trains an hour, according to the time of day, will be needed ; between the same points, by the cross-line passing the Hotel de Ville, from 8 to 16 trains per hour ; on the southern half of the circuit from 4 to 12 trains an hour, and on the southern cross-line from 4 to 6 trains an hour. It is not stated what number of passengers the trains are expected to carry, but to those who are accustomed to the requirements of traffic in New York or in London, this seems rather a small number of trains.

This plan, it is hoped, will present a solution of the problem which has caused the authorities of Paris so much trouble. To judge from the objections which have been raised to all the preceding ones, however, it seems doubtful whether even the eminent authority of M. Le Chatelier will be sufficient to secure its adoption without some modification.

THE USE OF WOOD IN RAILROAD STRUCTURES.

By Charles Davis Jameson, C. E.

(*Continued from page* 566, *Volume LXIII.*)

CHAPTER XIX.

DETAILS OF TRESTLE CONSTRUCTION.

The general design of all the standard wooden trestles, as shown by the accompanying plates, exhibits a great similarity, the differences in them being due more to local circumstances than to any radical differences in the ideas of the various designers.

With regard, however, to the methods used in carrying out the details of these designs, much difference of opinion prevails. There are two points upon which very few engineers agree :

1. The best method of holding together the joints.
2. The best design for the floor system, as regards safety and economy.

In what follows we wish merely to call attention to some of the different methods used in working out the details of these two points, together with some of the advantages and disadvantages connected with the use of each.

With regard to the details of the joints, the following methods are used, the generality of their use being about in the order given : Mortise and tenon ; dowels ; drift bolts ; bent metal plates or sockets.

The mortise and tenon joint, an example of which is shown in the details of all the standard trestles, is the one in most general use. Its use, in fact, may be called universal, and this notwithstanding the many obvious faults it has. These faults are as follows : First, the cost of construction.

Mortise and tenon joints necessitate a great deal of high-priced carpenter work. In order to meet the requirements all the work must be done with accuracy, and every surface brought to an even and exact bearing. This requires a great expenditure of both time and money, and of course the question is whether the result obtained is an equivalent. No matter how much care is taken with the work, the joints are never water-tight, and thus offer receptacles for the retention of a certain amount of moisture, which hastens decay in a very perceptible manner. All timbers framed together and exposed in such a manner as trestles, bridges, etc., decay at the joints long before any signs are visible at other points.

This decay at the joints renders it necessary to renew the timbers, and as all the stick is perfectly sound with the exception of the mortise and tenon, much good timber is rendered useless. Much of the timber, of course, can be cut down and used over again in some smaller structure, but it is at a cost that nearly counterbalances the gain.

Another disadvantage connected with the mortise and tenon joint is the fact that that portion of the wood utilized to withstand the superimposed weight is the poorest part of the timber, the outside of both timbers only bearing all the strain, while the heart of the timber does nothing. This is the result when only a single mortise and tenon are used. To some extent it is remedied by making two tenons, leaving a bearing surface between them, or, when the timber is sufficiently large, staggering the tenons. Either of these methods gives only a partial solution of the difficulty, and the great extra expense incurred in carrying them out more than counterbalances any gain. The effort is often made to cut the tenon and mortise with such accuracy that the end of the tenon will come to a bearing in the bottom of the mortise, thus utilizing this additional bearing surface. In order, however, to accomplish this object, such a superior class of workmanship is called for that the cost would be all out of proportion to the gain. When ordinary carpenters are employed, all idea of making use of this bearing surface should at once be abandoned, because, owing to the too slovenly manner in which the work is done, if any attempt is made to bring the tenon to a bearing in the mortise the result will be one of two things :

Either the tenon, being slightly too long, will carry all the weight and in a very short time split the cap or sill if the weight is sufficient, or else the tenon will be too short and all the bearing come on the shoulders, as usual, and the extra expense incurred in attempting what has not been accomplished will have been just so much waste.

There is another point also that renders it practically impossible ever to bring the end of the tenon and the shoulder of the joint to an uniform bearing, and it is the fact that the timber used is never thoroughly seasoned, and a certain amount of shrinkage takes place subsequently. This shrinkage occurs always across the grain of the wood to a greater extent than in the direction of the fibers, and therefore, from this shrinking, the depth of the mortise is decreased, while the length of the tenon remains practically the same. From this fact it will be seen that unless, when first framed, the tenon is made shorter than the depth of the mortise, in a very short time all the strain will be thrown upon the end of the tenon, the shoulders of the joint having shrunk away from each other.

The best rule to be followed in designing a mortise and tenon joint is to remember that the tenon must serve simply to hold the two pieces in place, and not to bear any of the strain. All of the strain must be borne by the shoulders, and when the two timbers do not come together at right angles, as in the case of the joints between the batter, posts and the caps and sills, the resulting horizontal thrust must be taken up, not by the tenon, but by cutting down the sides of the mortise until they are at right angles to

PLATE 71

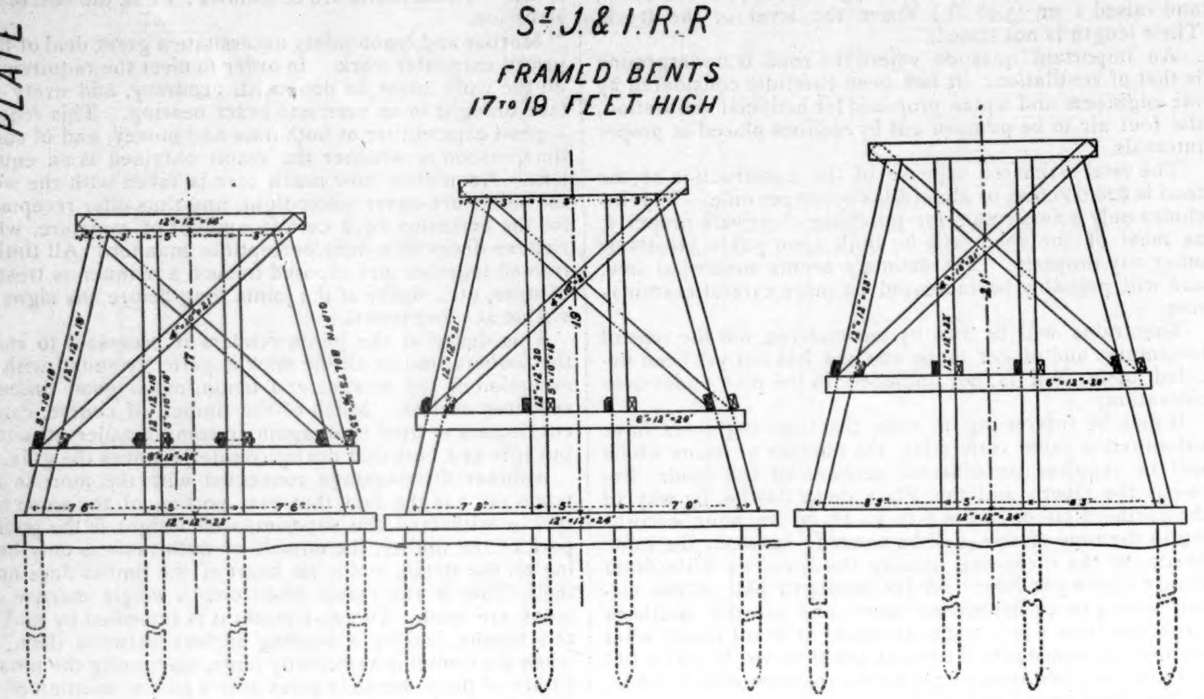


PLATE 70

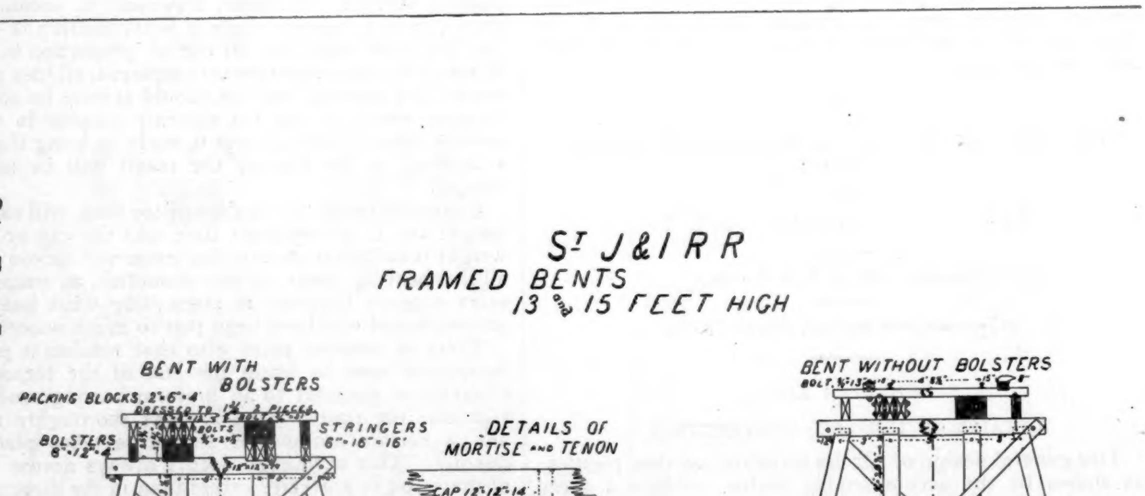


PLATE 72

ST J & I R R
FRAMED BENTS
23 TO 27 FEET HIGH

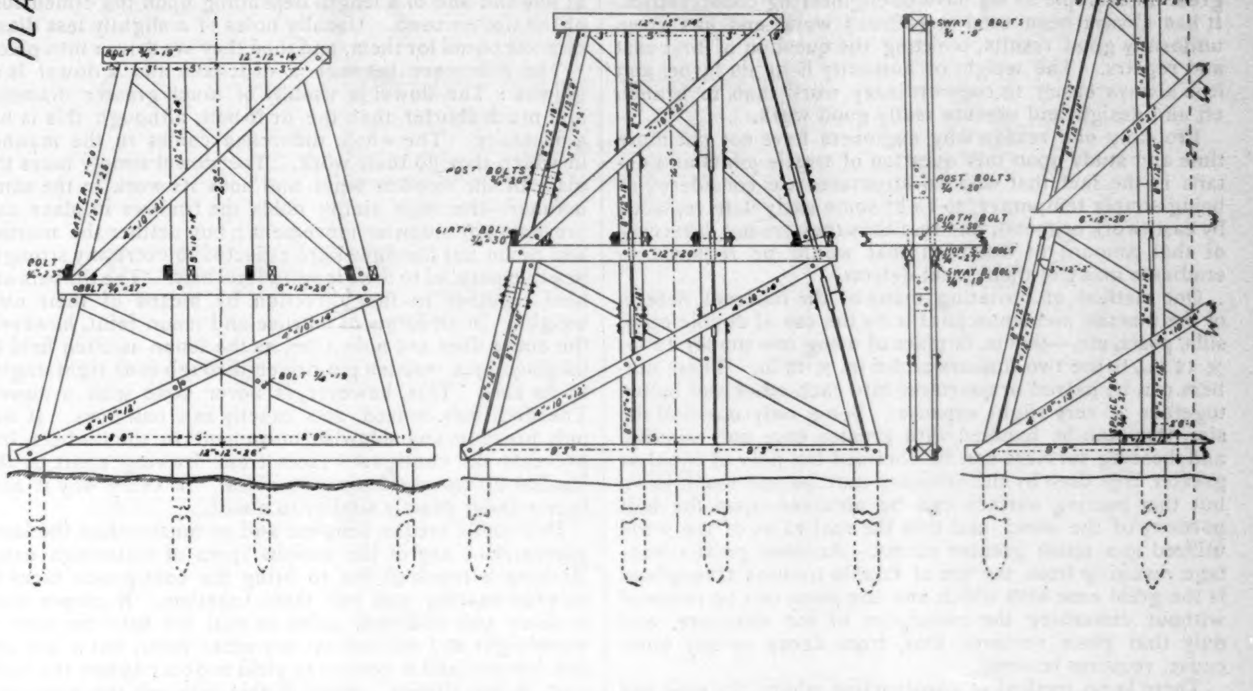
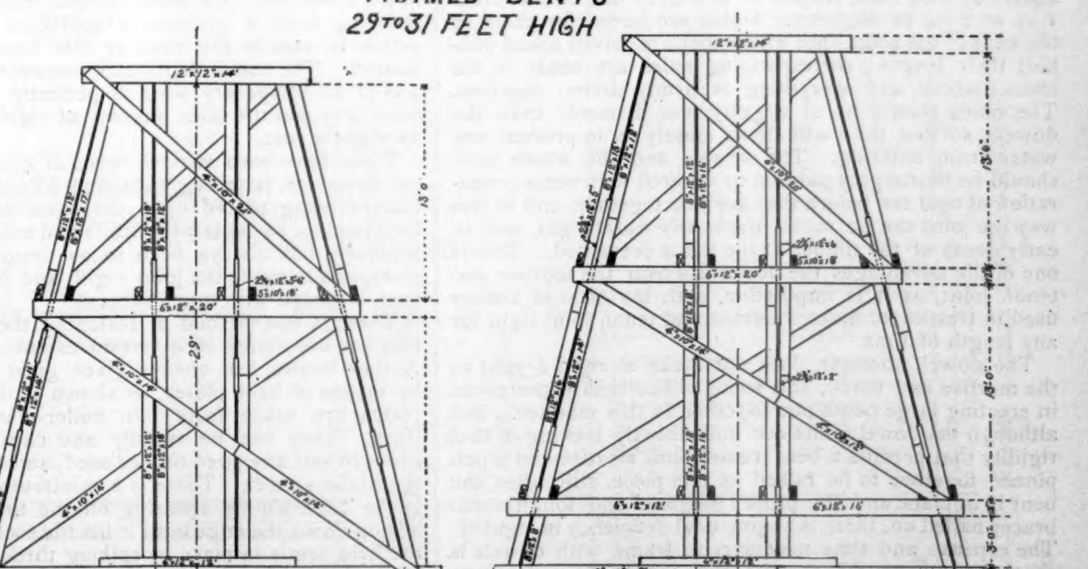


PLATE 73

ST. J. & I. R. R.
FRAMED BENTS
29 TO 31 FEET HIGH



the line of thrust. The tenon should be made as small as possible, and thus give as large a bearing surface to the shoulders as possible.

Notwithstanding all of these defects inherent in the mortise and tenon joint, it is the form in general use, and undoubtedly will continue such as long as wooden trestles are used.

The advantage connected with its use is a maximum of rigidity and stability to the structure. It is probably as great an example as we have of engineering conservatism. It has always been used in railroad work, and has given uniformly good results, omitting the question of first cost and repairs. The weight of authority is in its favor, and it is always easier to copy ordinary work than to branch off and design and execute really good work.

Probably one reason why engineers have not put more time and study upon this question of trestle joints and details is the fact that wooden structures are considered as being simply temporary, to be at some early date replaced by earthwork or metal, and that thus they are not deserving of that amount of attention that would be required to eradicate many of their great defects.

One method of obviating many of the inherent defects of the mortise and tenon joint is by the use of double caps, sills, posts, etc.—that is, in place of using one timber 12 in. × 12 in., to use two timbers each 6 in. × 12 in. These timbers can be halved or quartered into each other and bolted together at very slight expense. Being only one-half the size, they can be handled with greater ease and rapidity, and bearing surfaces can be obtained not only of equal or greater area than by the ordinary mortise and tenon joint, but this bearing surface can be obtained upon the best portions of the wood, and thus the real value of the wood utilized to a much greater extent. Another great advantage resulting from the use of double timbers throughout is the great ease with which any one piece can be renewed without disturbing the remainder of the structure, and only that piece removed that, from decay or any other cause, requires renewal.

There is no method of construction where the ease and economy of renewal can be rendered so great as in this. It possesses all the advantages that can be claimed for the ordinary mortise and tenon joint, while the disadvantages are reduced to a minimum. The quality of timber used is, for the same price, much superior, and the expense of handling it much less.

The second method of holding the trestle joints together is by means of dowels. These dowels are iron pins cut square at both ends, from 4 in. to 2 ft. in length, and from 1 in. to 2 in. in diameter. Holes are bored for them in the ends of the posts, into which they are driven about one-half their length; corresponding holes are made in the cross-timbers, and everything is firmly driven together. The holes should be of slightly less diameter than the dowels, so that they will fit so closely as to prevent any water from entering. The dowels and the whole joint should be thoroughly painted or covered with some preparation of coal tar before they are put together, and in this way the joint can be made practically water-tight, and an early decay of the timber at the joints prevented. This is one of the advantages the dowel has over the mortise and tenon joint, as it is impossible, with the class of timber used in trestles, to make a mortise and tenon joint tight for any length of time.

The dowel, however, does not make as rigid a joint as the mortise and tenon, and some difficulty is experienced in erecting large bents put together in this manner. But although the dowel joints are undoubtedly lacking in that rigidity that permits a bent framed with mortise and tenon pinned together to be raised as one piece, still, after the bent is in place and the proper diagonal and longitudinal braces nailed on, there is no practical deficiency in rigidity. The expense and time necessary to frame with dowels is much less than with mortise and tenon, the only thing necessary being to bring the contiguous surfaces to an even bearing and to bore the holes for the dowels. In timbers of a given size much less of the bearing surface is wasted by the use of the dowel than by use of the tenon.

The great disadvantage connected with the use of the dowel is the difficulty in making repairs and renewals. The dowels being of iron necessitates the taking down of the greater part of the bent in order to renew any one piece. In the mortise and tenon, the tenon can be cut off with a saw and the piece removed with comparatively little trouble, although with nothing like the ease and facility that is possible when split or double timbers are used.

The third method used is by means of drift-bolts. These bolts are usually of round iron ⅞ in. in diameter, pointed at one end and of a length depending upon the dimensions of the timber used. Usually holes of a slightly less diameter are bored for them, and then they are driven into place.

The difference between a drift-bolt and a dowel is as follows: The dowel is usually of much greater diameter and much shorter than the drift-bolt, although this is not a necessity. The whole difference comes in the manner in which they do their work. The dowel simply takes the place of the wooden tenon and does its work in the same manner—that is, it simply holds the timbers in place and prevents any sidewise movement; but neither the mortise and tenon nor the dowel are expected to exert any strength in a line parallel to their longitudinal axis. The timbers are held together in that direction by means of their own weight. In all forms of mortise and tenon joint, however, the above does not hold true, as the tenon is often held to its place by a wooden pin driven through it at right angles to its axis. This, however, is never done with a dowel. The drift-bolt, indeed, acts exactly as a nail does. It not only prevents any sidewise movement in the timbers, but prevents the contiguous faces from drawing apart by the friction of the wood upon its sides. In every way it acts in a manner exactly similar to a nail.

Drift-bolts are the simplest and in construction the least expensive of any of the various types of fastenings used. Nothing is required but to bring the contiguous faces to an even bearing and bolt them together. If proper care is taken and sufficient paint or coal tar used the joint is water-tight and will outlast any other form, but it will not last forever, and is certain to yield to decay before the main part of the timber. Even if this was not the case, still there would come a time when there was a necessity for renewal, and when this time arrives the great disadvantages of the drift-bolt are brought out. There is no practical means of extracting them, and the difficulty of renewing any one piece of a bent is so great that usually renewal is delayed until, in the opinion of the bridge foreman, the whole bent can be economically renewed. As no two pieces of timber are affected to the same degree by decay in the same time, the result is that either the bent is left standing until it becomes a source of positive danger, which is usually the case, or else some good timber is wasted. The use of drift-bolts, however, is very common, and in all temporary work is perfectly allowable. In no other way can the same amount of rigidity be obtained at so slight a cost.

There have been various forms of clamp used at different times for fastening caps and sills to the posts, these clamps being placed upon the sides of the timbers and held in place by bolts with heads and nuts. The difficulty, however, has always been to so design and fasten the clamps as to make the joint rigid, and their use has never been attended with much success.

There is one method of fastening the timbers together that has been tried to a certain extent, and, as far as the Author knows, has always given good results. That is by means of bent plates, as shown in Plate 77.* These plates are made from thin boiler-plate ⅛ in. to ¼ in. thick. They can be rapidly and cheaply made in the shops to suit any sized timber used, and any angle at which the timbers meet. There is a minimum of work required in the field, simply squaring off the timber and possibly adzing down the edge until it fits the socket. The timbers are held firmly in place by spiking through the bent sides, as shown in the sketch. The resulting joint has all the stiffness of the mortise and tenon. There is none of the expense attending the cutting of the mortise and tenon, and the metal plates tend to protect from decay the parts

* These bent plates are not used upon the Chicago, Rock Island & Pacific Railroad, and have nothing to do with the standard plans of that railroad that appear upon the same plate.

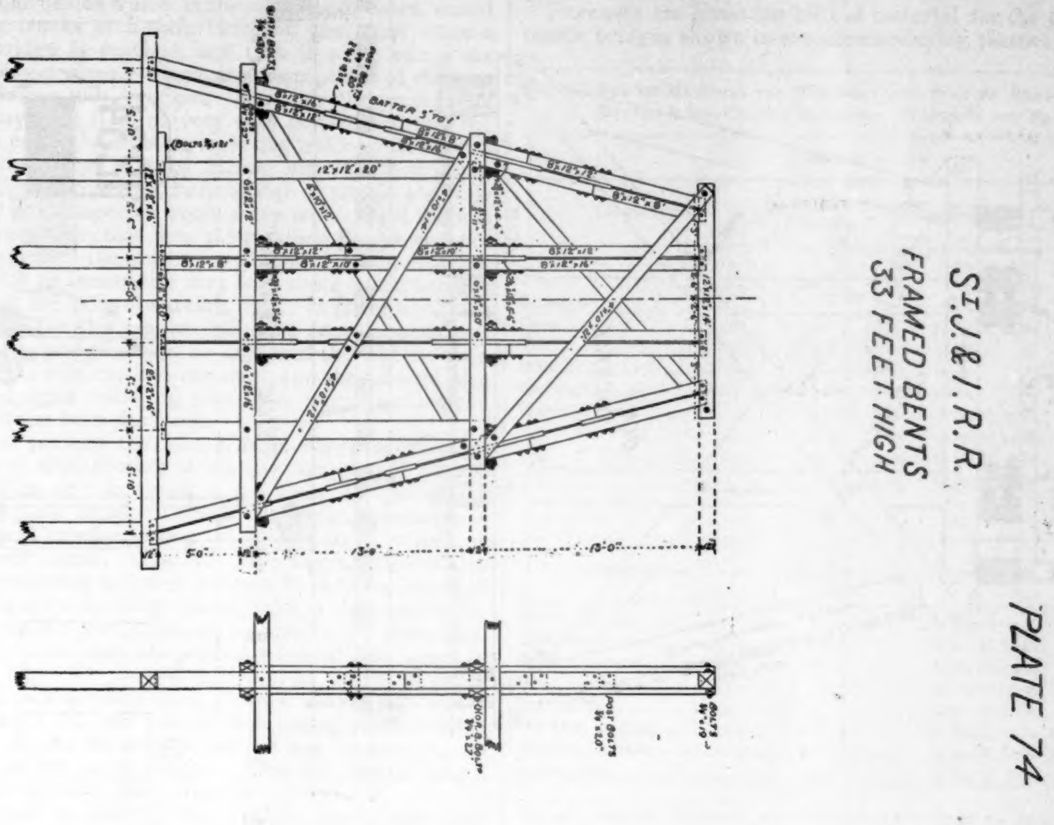


PLATE 74
St.J.&I.R.R.
FRAMED BENTS
33 FEET HIGH
BATTER 3" TO 1'

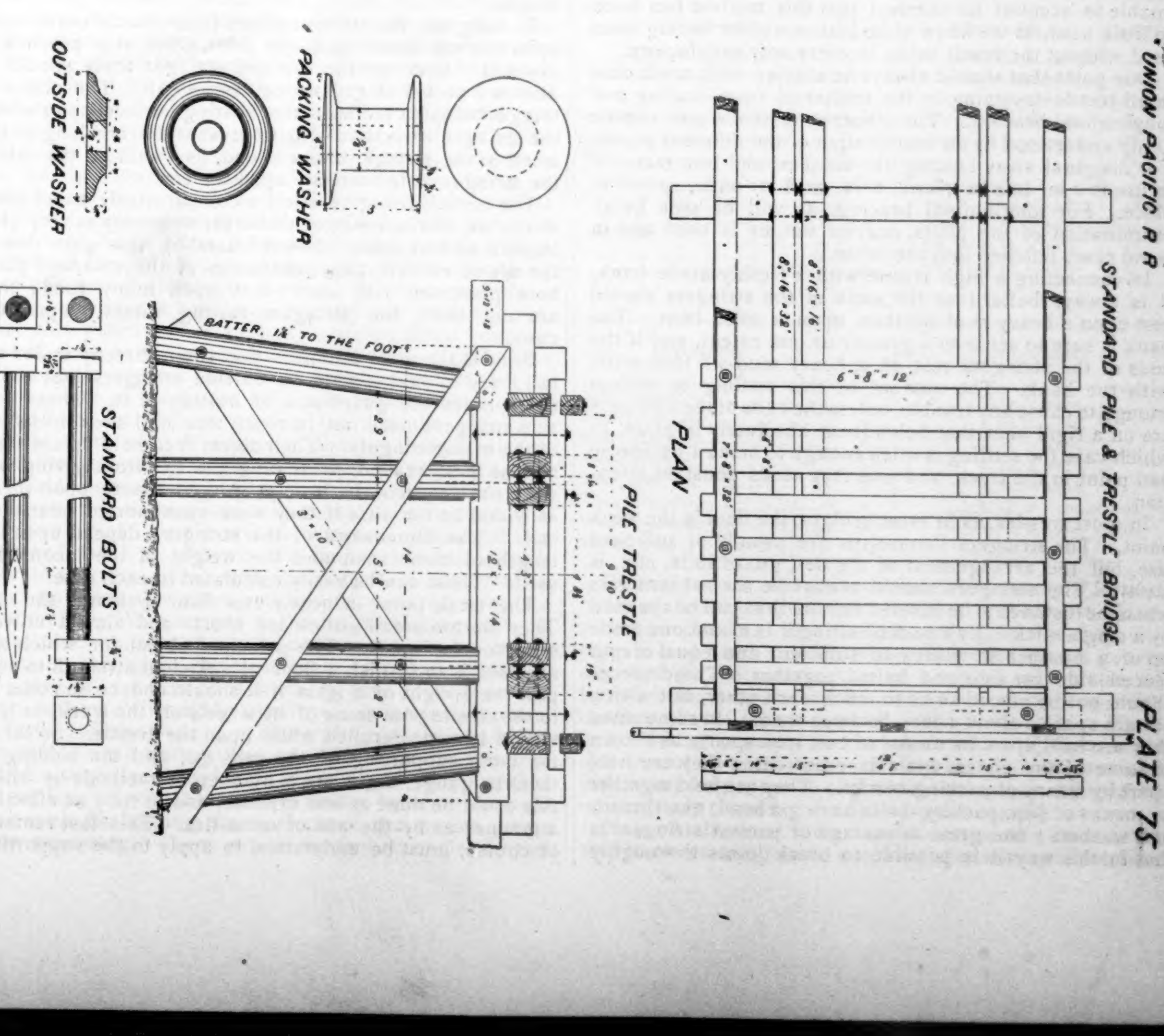
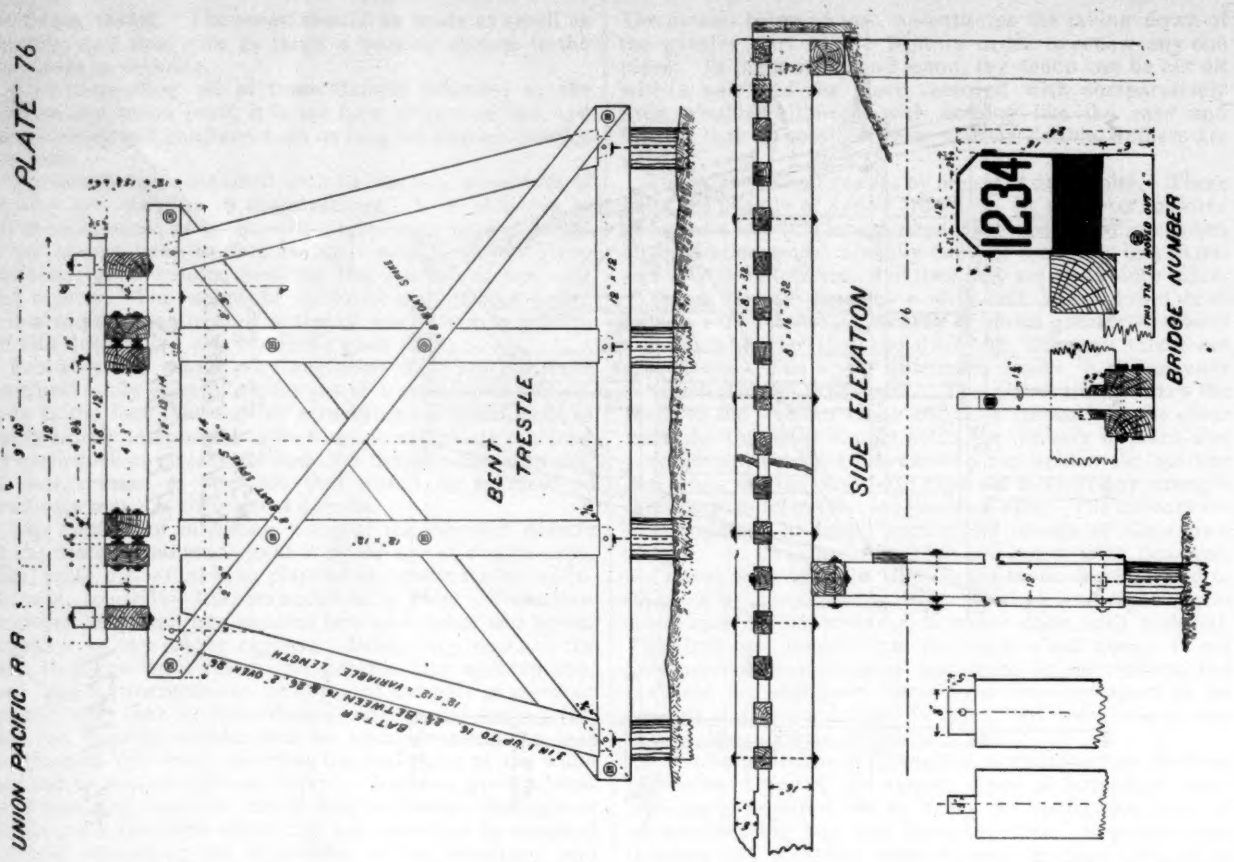


PLATE 75
UNION PACIFIC R R
STANDARD PILE & TRESTLE BRIDGE
PLAN
PILE TRESTLE
BATTER, 1¼" TO THE FOOT
PACKING WASHER
OUTSIDE WASHER
STANDARD BOLTS



of the timber with which they come in contact. We are unable to account for the fact that this method has been so little used, as we know of no instance of its having been used without the result being in every way satisfactory.

One point that should always be studied with much care in all trestle designing is the matter of sway-bracing and longitudinal bracing. The different methods used can be easily understood by an examination of the different plates. For diagonal sway-bracing the simplest and best material to use is 2 in. to 4 in. plank, 6 in. or 8 in. wide, spiked in place. For longitudinal bracing, as will be seen by an examination of the plans, heavier timber is used and in some cases notched into the bents.

In connecting a high trestle with a freshly-made bank, it is always better that the ends of the stringers should rest upon a heavy mud-sill than upon a solid bent. The bank is sure to settle to a greater or less extent, and if the ends of the stringers rest on a heavy mud-sill they settle with the bank. The amount of this settling is seldom enough to cause any trouble, unless the ends of the stringers are on a rigid bent that holds them absolutely in place, in which case the settling is often enough to make a decidedly bad point in the track, and one that needs constant attention.

In most trestles, as in most bridges, the floor is the weak point. The stringers themselves are usually of sufficient size, but the arrangement of the ties, guard rails, etc., is faulty. The stringers should always be packed stringers when the distance to be covered is more than can be spanned by a single stick. By a packed stringer is meant one made up of a number of pieces of sufficient and equal depth placed side by side and bolted together. These pieces should not be placed so as to touch each other, but with a certain space—about 1 in.—between them. In some cases they are held apart by means of cast-iron spools, as shown in some of the plates, while in other cases they are held apart by means of packing blocks. They are held together by means of ¾-in. packing-bolts having a head, nut, thread, and washers; one great advantage of packed stringers is that in this way it is possible to break joints thoroughly and practically to make a stringer of any dimension or any length.

In designing the stringer pieces there should never come upon one cap more than one joint, when it is possible to avoid it. Between the cap and stringer there should be always a corbel of greater or less length. The object of this corbel is to increase the bearing surface upon which the stringer rests, and also to prevent the crushing of the wood of the stringer under a load, as would be the case if the stringer rested directly upon the cap.

The corbel, being in itself a comparatively small piece of timber, can be renewed whenever necessary at very little trouble and expense. Notwithstanding this gain due to the use of corbels, an examination of the standard plans here presented will show that upon many roads they are not used, the stringers resting directly upon the caps.

Besides the main stringers that come directly under the rail there should always be outside stringers that either come under the guard-rail, or outside of it. These outside stringers need not be more than half the dimensions of the main stringers. Their object is to hold up the train in case it is derailed, preventing the ties from giving way when the weight of the train is brought directly upon them, as would be the case if they were unsupported near their ends. The dimensions of the stringers depend upon the length of clear span and the weight of the locomotive used. These can be easily calculated in each case.

The weak point in nearly ever floor system is the ties. They are too small—often too short—and almost universally too far apart. The principal object for which ties are used is to furnish a floor of sufficient strength to support the weight of a train if it should chance to come on to the trestle with some of its wheels off the track, or if it should become derailed while upon the trestle. So far as the mere supporting of the rails go, and the holding of them to gauge, there are a number of methods by which this could be done at less expense, and in fully as effective a manner as by the use of cross-ties. This last remark, of course, must be understood to apply to the supporting

of rails upon bridges, trestles, or similar structures, and not upon the ordinary embankment.

There is one device which, in the majority of cases, would prevent any trucks of a train being off the track when a trestle or bridge is reached, and that is some one of the many rerailing devices. Plans and descriptions of the best of these devices will be given later; for the present we will only say that it is of very rare occurrence that the wheels of a car or locomotive leave the track while upon a bridge or trestle, so that by having one of the rerailing devices at the approach to every bridge or trestle about 90 per cent. of the danger is done away with. Still there is always the possibility that first, the rerailing device may not in every case effect the object for which it is built, and second, that a car or locomotive may from some cause become derailed upon the bridge or trestle itself. In order to reduce to a minimum the evil results following such an accident, the floor of the bridge should be such that the wheels, even if not upon the rail, can run across it, and they should also be prevented from swinging round too far, or getting too great a distance from the track.

In order to prevent the wheels from dropping through the floor, and thus tearing it up, the ties should not be more than 6 in. or 7 in. apart in the clear, and should be of such a section as not to break under the hammer-like blows they will receive when a wheel or pair of wheels is bouncing over them. They will have to be fastened also in some manner that will prevent them from being bunched or driven together by these blows from a derailed truck. The usual size of tie used, as will be seen by the drawings, is 6 in. × 8 in., and they are generally placed 7 in. apart in the clear. With the present tremendous weight of locomotives and rolling stock used, the ties should not be less than 8 in. × 12 in. and placed 6 in. apart in the clear. The length of the tie should not be less than 12 ft., although 9 ft. is the usual length. This question of length will be taken up more fully later on.

With regard to holding the ties in place, they rest directly upon the main stringers and the outside stringers; on top of the ties rest the rails that are spiked to each tie. This spiking, however, does very little to prevent the ties from being bunched in case of accident, as the heads of the spikes slip easily along the flanges of the rail. On each side of the track, and about 4½ ft. or 5 ft. from the center, are placed the guard-rails. These guard-rails are usually 8 in. × by 8 in. in size, and they should be notched down over the ties at least 1 in. The outside stringers should be directly under the guard-rail, and then ¾-in. bolts, with head and nut, should pass through the guard-rail, tie, and outside stringer, and thus everything be firmly bolted together. These bolts need not be used at every tie, but about every third tie will be sufficient. At points near bents these bolts should run down through the ends of the corbels, if they are used; if not, everything should be bolted directly to the cap. In every case these bolts should have a head and nut and not be drift-bolts. When this guard-rail is properly notched down over the ties and then firmly bolted in place, it will be impossible for the ties to become bunched in case of accident.

The object of the guard-rails is to prevent the wheels, when off the track, from running too near the edge, and to guide them in their course across the bridge; also to prevent the trucks from getting slowed to such an extent as to catch between the ties and tear them up. The upper inside angle of these guard-rails should be protected by a ½-in. angle-plate, firmly spiked to place. This will not only tend much to preserve the timber, but will also do away to a great extent with the danger of any derailed wheel mounting the guard-rail and thus getting upon the outside of it. With regard to the length of cross-ties, as was said before, they should be not less than 12 ft. In the first place, this gives sufficient room to properly arrange the guard-rail; it also adds much, or may be made to add much, to the stability of the structure. In the second place, it affords sufficient space to allow of a man being on the structure while a train is passing. This is something that should always be thought of, especially in long trestles. In very long trestles there should always be some arrangement made for holding the hand-car of the section gauge when necessary. There are some few examples in this country where this has been provided for, but they are altogether too few.

Herewith are given the bills of material for the pile and trestle bridges shown in the accompanying plates:

No. 35. Bill of Material for One Bent and Span of Bent Bridge, Denver & Rio Grande Railroad. Plates 68 and 69.

Lumber.

Description.	No. of Pieces.	Dimensions.	Ft. BM.
Guards	1	7 in. × 8 in. × 32 ft.	149 1/3
Ties	16	8 in. × 8 in. × 12 ft.	1,024
Stringers	3	8 in. × 16 in. × 32 ft.	1,024
Caps	1	12 in. × 12 in. × 14 ft.	168
Posts	4	12 in. × 12 in.	
Sills	1	12 in. × 12 in.	
Bracing	2	3 in. × 10 in.	
Plank for ends	3	3 in. × 8 in. × 3 ft.	18
" " "	1	3 in. × 12 in. × 14 ft.	42
" " "	1	3 in. × 12 in. × 16 ft.	48
" " "	1	3 in. × 12 in. × 18 ft.	54

Iron.

Description.	No. of Pieces.	Dimensions.
Bolts, packing	8	¾ in. × 22 in.
Bolts, tie to cap	2	¾ in. × 38 in.
Bolts, guard-rail	8	¾ in. × 33 in.
Bolts, bracing	8	¾ in. × 18 in.
Bolts, drift	4	¾ in. × 18 in.
Washers, packing	8	¾ in. × 3 in. × 4 in.
Washers, outside	52	¾ in. × ⅝ in. × 4 in.
Spikes, boat	20	½ in. × 8 in.

No. 36. Bill of Material for One Bent and Span of Pile Bridge Denver & Rio Grande Railroad. Plates 68 and 69.

Lumber.

Description.	No. of Pieces.	Dimensions.	Ft. BM.
Guards	1	7 in. × 8 in. × 32 ft.	149 ⅓
Ties	16	8 in. × 8 in. × 12 ft	1,024
Stringers	3	8 in. × 16 in. × 32 ft.	1,024
Caps	1	12 in. × 12 in. × 14 ft.	168
Piles	4		
Bracing	2	3 in. × 10 in.	
Plank for ends	3	3 in. × 8 in. × 3 ft.	18
" " "	1	3 in. × 12 in. × 14 ft.	42
" " "	1	3 in. × 12 in. × 16 ft.	48
" " "	1	3 in. × 12 in. × 18 ft.	54

Iron.

Description.	No. of Pieces.	Dimensions.
Bolts, packing	8	¾ in. × 22 in.
Bolts, tie to cap	2	¾ in. × 38 in.
Bolts, guard-rail	8	¾ in. × 33 in.
Bolts, bracing	8	¾ in. × 18 in.
Bolts, drift	4	¾ in. × 22 in.
Washer, packing	8	⅜ in. × 3 in. × 4 in.
Washer, outside	52	¾ in. × ⅝ in. × 4 in.
Spikes, boat	18	½ in. × 6 in.

We wish to call especial attention to the standard framed bents of the St. Joseph & Iowa Railroad, as shown in Plates 70 to 74 inclusive. The characteristic points in these designs is that much smaller timber is needed than is generally used in the construction of bents of such a size, no timber being larger than 8 in. × 12 in., 16 ft. long, with the exception of the caps, which are 12 in. × 12 in. There is no timber required in the construction of these bents that cannot be purchased at any lumber yard, and it would well repay engineers to put more study upon designs requiring only timber of the ordinary dimensions.

Plate 78 shows a rather novel design of a built beam that has been used with much satisfaction upon the New

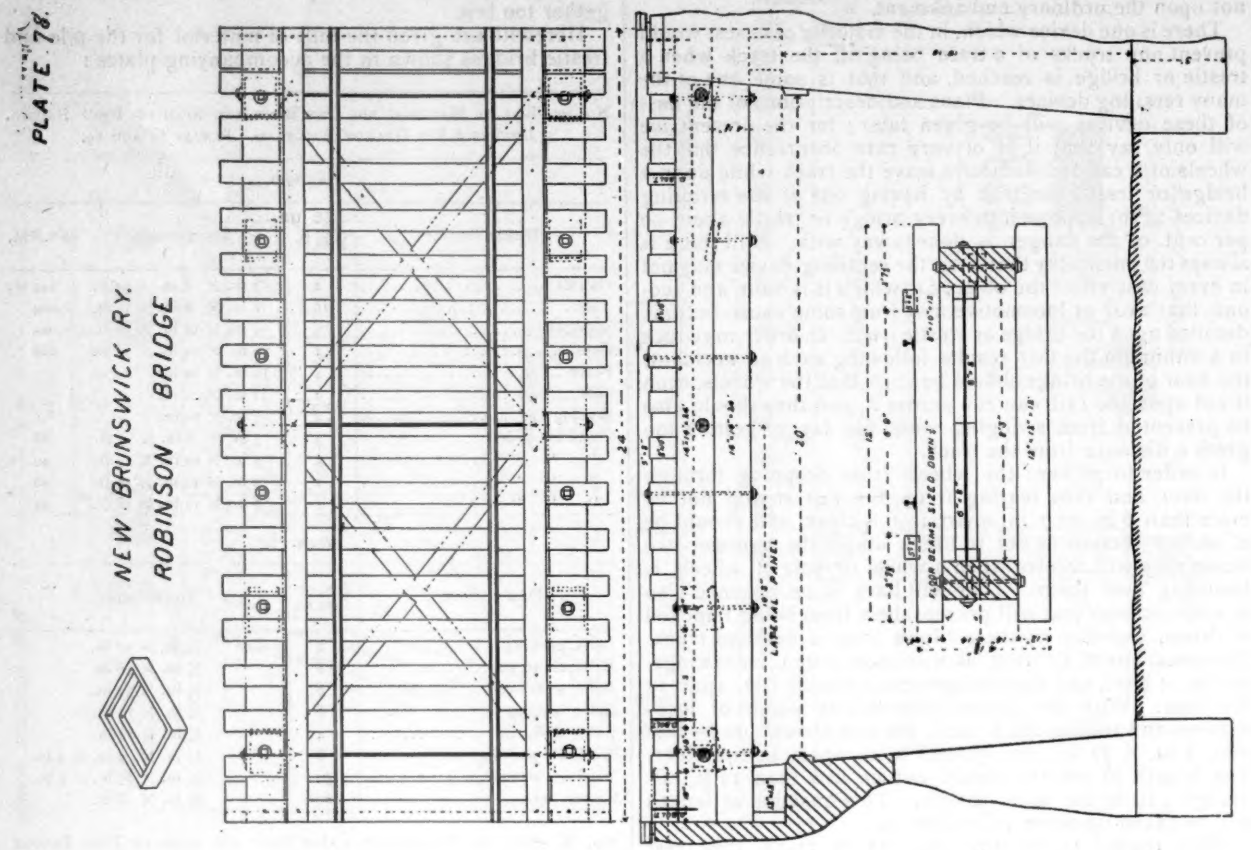


PLATE 78
NEW BRUNSWICK RY.
ROBINSON BRIDGE
FLOOR BEAMS SIZED DOWN
LENGTH OF PANEL

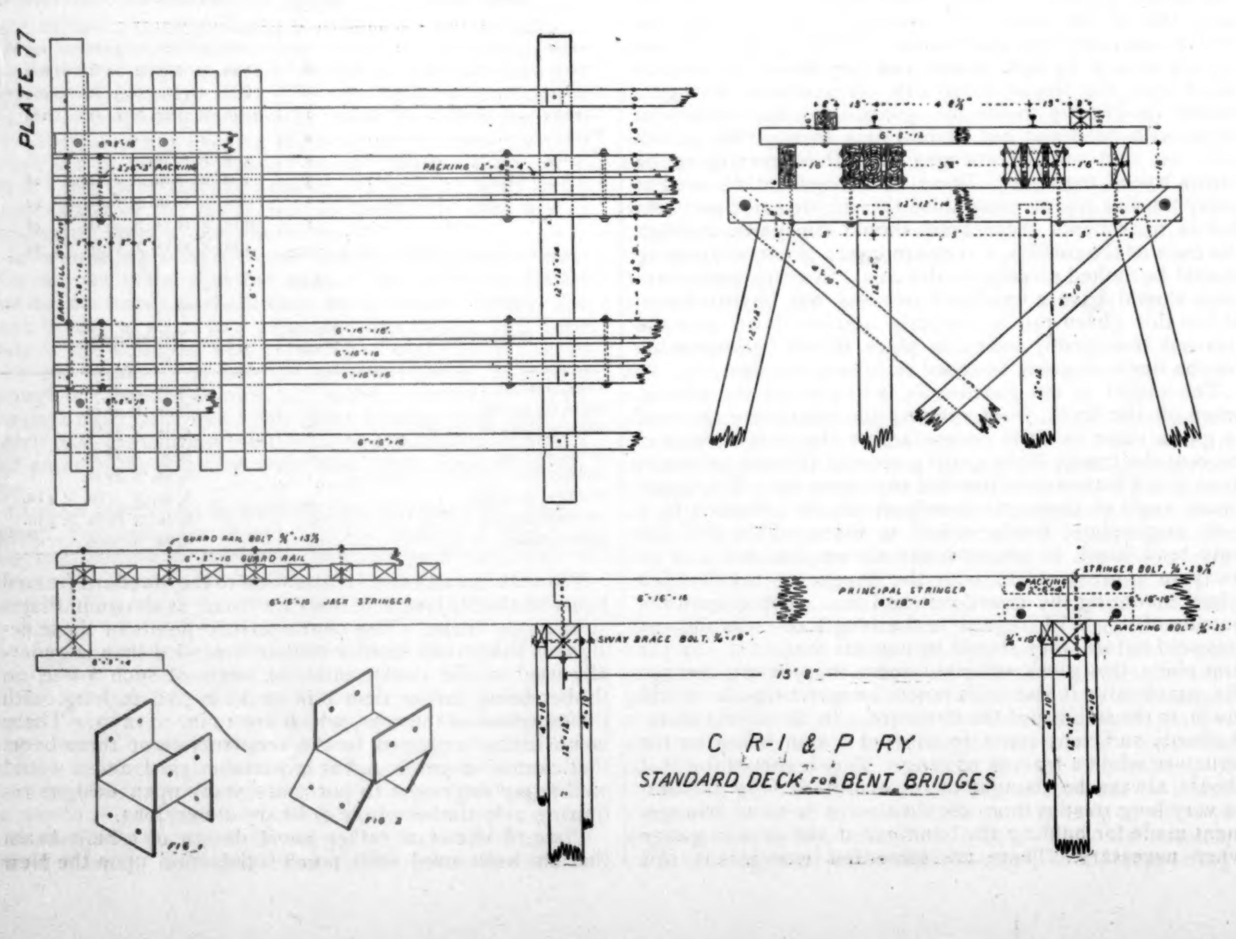


PLATE 77
PACKING
BANK SILL
GUARD RAIL BOLT
GUARD RAIL
JACK STRINGER
SWAY BRACE BOLT
PRINCIPAL STRINGER
STRINGER BOLT
PACKING BOLT
FIG 1
FIG 2
C R-I & P RY
STANDARD DECK FOR BENT BRIDGES

No. 37. Bill of Material for One Bent and Span of Trestle Bridge, Union Pacific Railway. Plates 75 and 76.

Lumber.

Description.	Kind.	No. of Pieces.	Dimensions.	Ft. BM.
Sills	Pine.	1	12 in. × 12 in.	
Posts....................	"	4	12 in. × 12 in.	
Caps.	Oak.	1	12 in. × 12 in. × 14 ft.	168
Stringers (see note)......	Pine.	6	8 in. × 16 in.	1,024
Ties....	Oak.	12	6 in. × 8 in. × 12 ft.	576
Guards (see note).......	Pine.	2	7 in. × 8 in.	149
Bracing....	Oak.	2	3 in. × 10 in.	
Plank for end span......	Pine.	1	3 in. × 12 in. × 14 ft.	42
" " " "	"	1	3 in. × 12 in. × 16 ft.	48
" " " "	"	1	3 in. × 12 in. × 18 ft.	54
" " " "	"	3	3 in. × 12 in. × 3 ft.	18

Note.—Guards and stringers 32 ft. long, breaking joints.

Iron.

Description.	No. of Pieces.	Dimensions.	Weight
Bolts, packing..................	8	3/4 in. × 22 in.	26.6 lbs.
Bolts, tie to cap................	2	3/4 in. × 36 in.	10.1 "
Bolts, tie to stringer guard......	8	3/4 in. × 31 in.	35.5 "
Bolts, bracing.....	8	3/4 in. × 18 in.	22.5 "
Washers, packing....	8	3/4 in. × 3 in. × 4 in.	
Washers, outside....	52	3/4 in. × 5/8 in. × 4 in.	
Spikes, boat....................	20	1/2 in. × 8 in.	
Drift-bolts where piles are used..	4	3/4 in. × 18 in.	

Note.—Use either the Harvey nut, or jam-nuts.

No. 38. Bill of Material for One Bent and Span of Pile Bridge, Union Pacific Railway. Plates 75 and 76.

Lumber.

Description.	Kind.	No. of Pieces.	Size.	Ft. B. M.
Piles....................	Oak.	4		L. F.
Caps...................	"	1	12 in. × 12 in. × 14 ft.	168 BM.
Stringers (see note.)...	Pine.	6	8 in. × 16 in.	1,024 "
Ties....................	Oak.	12	6 in. × 8 in. × 12 ft.	576 "
Guards (see note.)...	Pine.	2	7 in. × 8 in.	149⅓ "
Bracing.................	Oak.	2	3 in. × 10 in.	"
Plank for end span....	Pine.	1	3 in. × 12 in. × 14 ft.	42 "
" " " "	"	1	3 in. × 12 in. × 16 ft.	48 "
" " " "	"	1	3 in. × 12 in. × 18 ft.	54 "
" " " "	"	3	3 in. × 8 in. × 3 ft.	18 "

Note.—Guards and stringers 32 ft. long, breaking joints.

Iron.

Description.	No. of Pieces.	Size.	Weight
Bolts, packing..................	8	3/4 in. × 22 in.	26.6 lbs.
Bolts, tie to cap..	2	3/4 in. × 36 in.	10.1 "
Bolts, tie, stringer and guard....	8	3/4 in. × 31 in.	35.5 "
Bolts, Bracing..................	8	3/4 in. × 18 in.	22.5 "
Washers, packing...............	8	3/4 in. × 3 in. × 4 in.	
Washers, outside................	52	3/4 in. × 5/8 in. × 4 in.	
Spikes (boat)...................	20	1/2 in. × 8 in.	
Drift-bolts	2	3/4 in. × 22 in.	

Note.—Use either the Harvey nut, or jam-nuts.

Brunswick Railway. It was designed by Moses Burpee, Chief Engineer of the road, to whose kindness the Author is indebted for the plans and description. It is designed to be used when a single stick of sufficient size is not available. The two pieces put together in this manner are nearly as strong as a single stick of the same dimensions. The most economical proportions to be used in this case are about a depth of two to a width of one. The details of construction can be easily understood by a careful study of the drawing. The brace-blocks shown in figs. 1 and 2 are of cast iron. It will be noticed that they are of less width than the timbers with which they are used. The object of this is to obviate the necessity of cutting the edges of the timbers, and thus preventing to a great extent the entrance of moisture to the joint. The number of these brace-blocks used depends upon the length and dimensions of the timber used.

It is well, in designing this beam, to calculate for a camber, which should be about one-half the deflection of a solid beam of the same size under the given load. The object of this is to insure the bottom stick being in tension when loaded. This camber is easily given to the beam by increasing the distance between the seats of the braces in the top stick slightly over those in the bottom stick; the proper amount can be easily calculated. A bolt runs through both sticks and a hole in the center of the brace-block, and holds everything firmly together. To put the beam together, it is necessary to lay the bottom stick "work-wise" and clamp it in shape of camber so as to stretch the top of it sufficiently to receive the brace-blocks and the top stick; or it may be laid straight and the brace-blocks put in place, with their upper ends raised and propped up with a little stick just sufficient to hold the weight of the casting. Then, when the top stick is put in position and the bolts tightened up, the beam will be brought to a camber.

This is only another example of how two small pieces of timber may be made to do the work of one large piece when it is impossible or not advisable to procure the requisite large piece.

(TO BE CONTINUED.)

A NEW RUSSIAN BATTLE-SHIP.

(From the *Morskoi Sbornik.*)

THE latest addition to the Russian Navy is the armored battle-ship *Nicholas I.*, which was begun in 1886, and which has been built by the Franco-Russian Company under contract. The vessel is of steel of Russian manufacture, furnished by the Alexandroffski and the Putiloffski Works; the armor-plates were made at the Admiralty Works at Ijorski.

The chief dimensions of the *Nicholas I.* are as follows: Length between perpendiculars, 333½ ft.; length over all, including ram, 347½ ft.; breadth, 67 ft.; average draft, 23 ft.; displacement, 8,440 tons.

The belt armor is continuous, and is 8 ft. 2 in. wide; of this width, at the normal draft, 5 ft. is above the water-line and 3 ft. 2 in. below it. The compound armor-plates are 14 in. thick at the top, diminishing or tapering to 8 in. at the lower edge. The wood backing is of larch. The conning-tower is plated with 8-in. steel, and the turret, in which are carried two 12-in. guns, is plated with 10-in. steel.

In addition to the turret the ship has an armored redoubt or barbette above the main or armored deck, and in this additional guns are carried. In other words, the so-called barbette and turret systems are combined in its design. The turret is operated by hydraulic machinery, and every possible method of economizing space has been used, so as to give room for working the guns.

Provision is made for artificial ventilation below the deck, as well as for supplying forced draft to the boilers. The condensers are double, the first set supplying fresh water to the boilers, while from the second water for drinking purposes, for the supply of the crew, is obtained.

Like almost all modern war-vessels, the ship has twin screws. Each screw is driven by a triple-expansion engine having cylinders 39 in., 57 in., and 85 in. in diameter, and 38½-in. stroke. The engines are so arranged that the low-pressure cylinders can be detached from the others and worked separately. The propellers are of phosphor-bronze, and have four blades each.

There are 12 cylindrical boilers, each with three furnaces. These boilers are independent of each other, so that any injury to one will not affect the others—an important consideration in a fighting ship. The boilers are

each 13 ft. in diameter and 10 ft. long, and carry a working pressure of 125 lbs. The total weight of the machinery and boilers—including water in the boilers—is 1,100 tons.

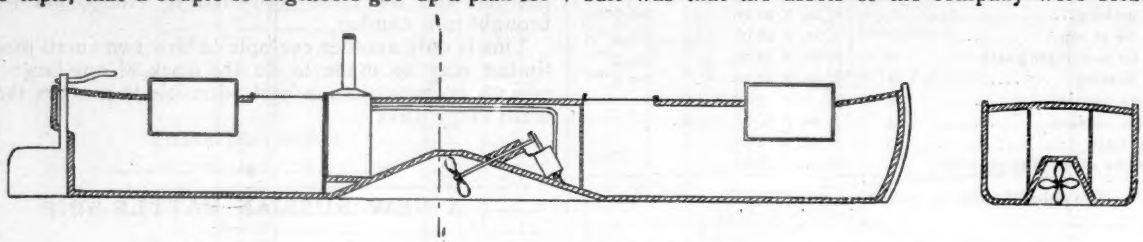
In the contract it was provided that the coal consumption at full power should not exceed 2 lbs. per indicated H.P. per hour. The trials on the measured mile, and also in a six hours' test in continuous working, showed that this condition had been fulfilled. On these trials the engines developed about 8,000 H.P. The speed attained by the ship is not stated.

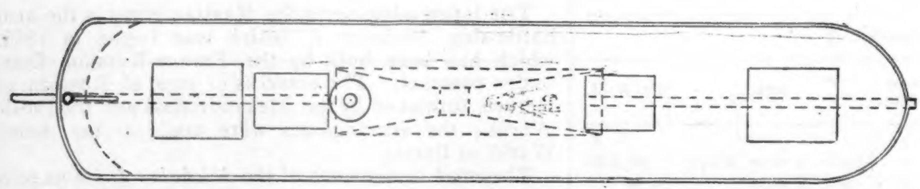
PROPELLING ON LIGHT DRAFT.

By Aloha Vivarttas.

In view of the recent experiments of M. Oriolle, of Nantes, France, as described in the Railroad and Engineering Journal of December, 1889, perhaps the history of the *Central* of New York may be interesting.

It happened that in the earlier seventies, while a memorable offer of $100,000 for the best method of steam propulsion on canals, made by the State of New York, was yet on the tapis, that a couple of engineers got up a plan for propelling vessels by means of a screw propeller located near the center of the boat, and working in a trunk analogous to that of an ordinary center-board, but wider, and closed over at the top.





The idea was not entirely new, but there was room for a great deal of judgment in carrying it out.

In 1876 a company, consisting of a dozen or more gentlemen, was formed, under the cognomen of the Central Propelling Company, for the purpose of applying the above invention to vessels, especially canal-boats.

An Erie canal-boat was purchased and a hole cut in her bottom, the trunk built in, and engines, boiler and propeller fitted complete.

Her general dimensions, without going into details, were as follows: Length, 96 ft.; beam, 17 ft.; depth, 11 ft.; load draft, 6 ft.; light draft, 2 ft; one propeller, diameter, 5 ft.; two engines, with cylinders 8 in. × 24 in., with boiler, surface condenser, etc. The accompanying sketch gives a fair idea of the general arrangement.

Her displacement at the load line was 240 tons, giving her a freight-carrying capacity of about 185 tons.

When all was complete, and her name duly changed to the more appropriate one of *Central*, a committee of the investors went aboard and the trial trip commenced.

Going up the Hudson light—that is, drawing about 2 ft. of water—she was reported as making six miles an hour easily, and, in spite of some heavy weather in Haverstraw Bay, Albany was passed, and the "raging canawl" boldly entered.

In the passage up the canal the boat puzzled all of her old acquaintances by carrying a smokestack but no apparent propeller, sliding smoothly along at a good rate of speed, which had no visible means of support.

After various incidents, more interesting to the spectators than to the public, Buffalo was reached, a cargo of corn secured, and the *Central* started down the canal.

Of the return trip it is related that, in crossing a long viaduct near Lockport, the boat had but a few inches of water under her keel, yet the propeller had no lack, and the speed was good.

On another occasion something got adrift in one of the steam-chests, and that cylinder was disconnected and the boat driven by one engine only without noticeable diminution of speed, which was easily maintained at 2½ miles per hour.

The voyage ended at New York, and it was found, upon figuring up the books, that the cost of coal and commissary stores had run ahead of the receipts in freight money. But the propeller had done its work well, and demonstrated the correctness of its arrangement and the general plan of the invention.

The patents were now taken out and assigned to the company. The boat was laid up for the winter in Gowanus Bay.

The next spring the *Central* was overhauled, and in June or July, 1877, a second trip was made to Buffalo and back. But by this time dissension had crept into the council chamber, differing men pulled different ways, and the result was that the assets of the company were sold out. The boat returned to her old practice of dancing on a taut tow-line, and the patents dropped out of sight in the safes of some one or two parties who had other matters to attend to, and they have remained in the chrysalis state ever since.

Of this plan of propulsion it may be said, in the light of the above-described experiment, that it has a wide field and is capable of giving good results if properly handled, but, like a blooded horse, it will disappoint the man who does not understand it. It shows, however, that M. Oriolle's plan was substantially anticipated some 13 years ago.

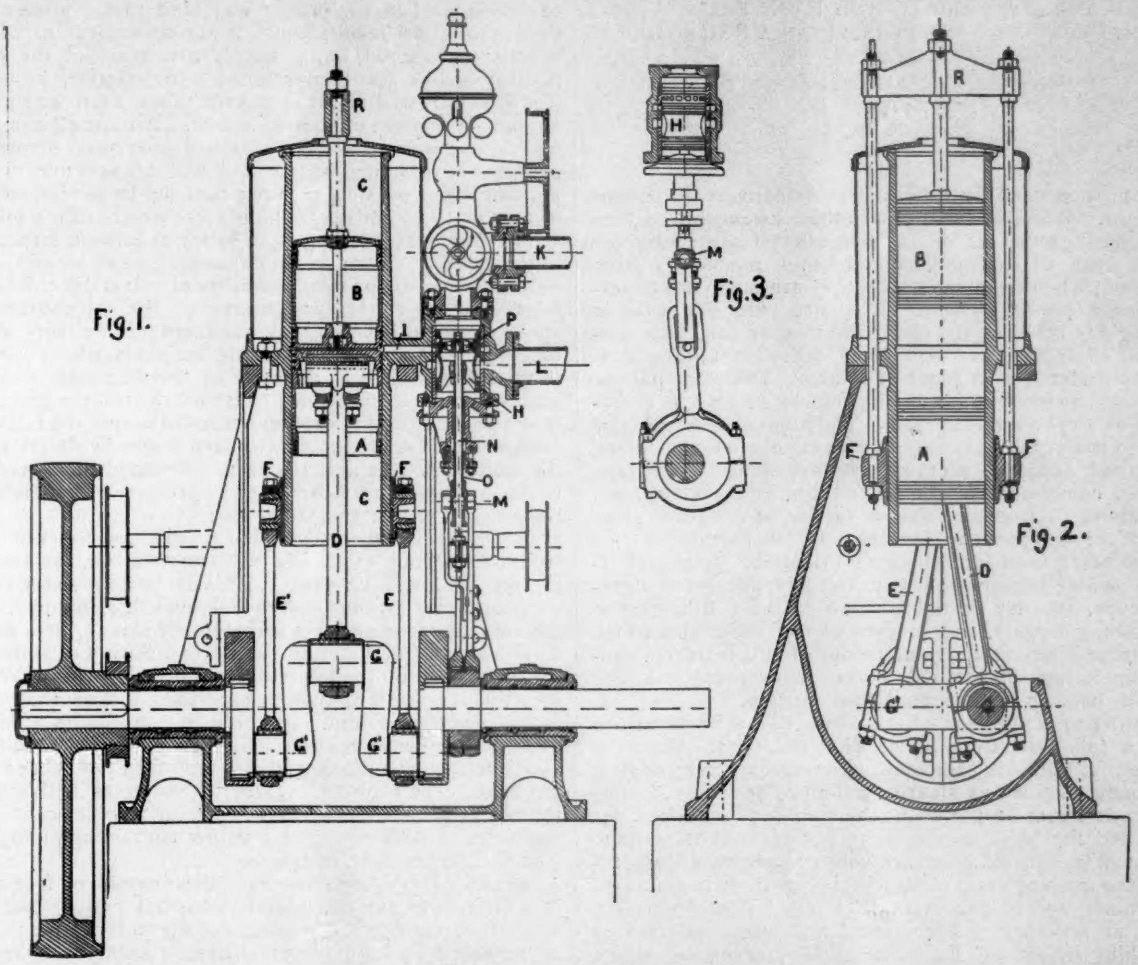
THE BÜRGIN HIGH-SPEED ENGINE.

(From the *Practical Engineer*.)

This is an interesting example of the single-acting type of high-speed engine, which presents some peculiarities special to itself. It is exhibited in the Swiss section of the Paris Exhibition, and is intended to solve the difficult problem of attaining perfect balancing in a high-speed reciprocating engine. The novel departure consists in the use of two pistons, working in a common cylinder, and so connected to the driving cranks that in all positions equal weights of pistons and rods are moving in opposite directions. There have been several attempts to balance by a somewhat similar construction, but this is the first arrangement of a single-acting engine with pistons moving in opposite directions of which we are aware. If we remember aright, Messrs. Lamberton, of Glasgow, exhibited an

engine of the double-acting type, in which this desirable feature was ingeniously accomplished. Referring to our illustrations, fig. 1 is a vertical section through the length of the crank-shaft, fig. 2 is a similar transverse section, and fig. 3 is a separate illustration of the piston valve and eccentric. The lower piston *A* and the upper piston *B* work in a long open cylinder *C*, common to both; and the lower piston connects to the center crank-pin *G* by the connecting rod *D*, while the upper piston is attached to a cross-head *R* by a rod shown, which cross-head connects in turn to a sliding ring *F F* fitting nicely on the machined exterior of the lower end of the long cylinder *C*. Connecting rods *E E*¹ link this sliding ring to two crank-pins, *G*¹ *G*¹, which are formed by bending, so that their centers fairly oppose the pin *G*—that is, the pins are separated on the crank circle by 180°, or half a circle. The construction of such a crank-shaft requires care, to ensure the two pins *G*¹ *G*¹ being truly in line; and as space is highly important, the arrangement is somewhat unusual. However, we shall describe that point directly. Steam is admitted between the pistons by the port *I*, controlled by the piston-valve *H*. In the position shown in fig. 1, the exhaust stroke has just been completed, and the steam is about to be admitted; the two pistons are thereby pushed apart, and the position at about half stroke is shown at fig. 2. When the stroke is completed, the exhaust is opened, and the pistons return to meet in the middle, as shown in fig. 1. By arranging the weights of the two pistons and their connections to be equal to each other, a most perfect balance is secured, and high speeds can be readily run with the greatest smoothness.

We are informed that this engine runs at 500 revolutions per minute without the smallest vibration. The piston-valve *H* is actuated from the eccentric rod *M*, through the sleeve or hollow rod *O*, in which works the rod *N*, through a stuffing-gland driving the internal expansion valve *P*. The piston-valve is therefore double, and consists of an internal and an external piston. The external serves as the ordinary main steam-valve, while the internal serves as the expansion or cut-off valve. They are driven by separate eccentrics. The live steam is admitted by the pipe *K* and passes through the interior of the piston-valve by ports shown more clearly in fig. 3. The valve is single-acting, of course, as the engine is single-acting. The exhaust escapes at the proper time by the annular passage shown in the exterior of the main piston-valve, and by the pipe *L*. The governor is of the throttle type, and is part of the inlet steam valve. The governor is driven by belt from the main shaft by the pulleys and intermediate shaft seen in fig. 1. The cranks *G* *G*¹ *G*¹ are formed by bending, and are connected to the crank-shaft by disks, made in halves and bolted together, as may be seen from figs. 1 and 2. The connecting rods are of special construction, and have springs, arranged as shown in fig. 1, to keep the brasses tight and prevent knock on the up-stroke. It is a common belief that pressure is always upon the crank-pins of single-acting engines, because there is no driving effort from steam upon the idle stroke; but this is a mistake. During the first half of the idle stroke there is always pressure upon the crank-pin, because the pin is doing work upon the piston and connecting rod, by causing their motion to be accelerated; but during the latter half of the stroke the piston is pulling on the crank-pin, as the speed is slowing down. Unless the cushioning is very early and great, this cannot be avoided. By using springs, Mr. Bürgin insures that all slack shall be taken up, and this avoids shock when nearing the end of the stroke.



THE BÜRGIN HIGH-SPEED ENGINE.

Mr. Bürgin's engine is constructed by the Société de Constructions Méchaniques, Bâle, Switzerland, and is well

worth careful study as a most ingenious piece of mechanism, which possesses many good points. The whole design is neat and substantial, and quite worthy of the high reputation of the Swiss makers.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS.
II. TALLOW.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page 557, Vol. LXIII.*)

TALLOW is used by railroads principally as a cylinder lubricant. It is also used, to a limited extent, mixed with white lead ground in oil, as a means of protecting the bright work of locomotives and other machinery from corrosion, when from any cause they are taken out of service for a period of time. It is also used somewhat in treating hot boxes on the road, and may be used as a constituent of lubricants. On some railroads tallow-oil is used by preference in place of tallow. The principal use of tallow, however, so far as our knowledge goes, is everywhere as a cylinder lubricant. The amount used for this purpose is so great, that the figures, to one unaccustomed to railroad accounts, seem almost incredible. Any large railroad company may use on its lines, in one year, from 750,000 lbs. to 1,000,000 lbs. of tallow, at a cost of from $60,000 to $80,000, by far the largest portion of this amount being used for cylinder lubrication. It is gratifying to be able to state, that with the introduction of sight-feed cups, the use of tallow as a cylinder lubricant is diminishing largely, and in view of the difficulties which seem to be inseparable from the use of this material, railroad operating officers will certainly welcome the day when its use can be dispensed with entirely.

In order to make clear what follows, it will be necessary to get a full understanding of what tallow is. Speaking chemically, tallow is principally a mixture of three neutral fatty bodies, known as stearin, palmitin, and olein. The stearin is about 61 per cent., the palmitin is about 6 per cent., and the olein is about 33 per cent. of the tallow. The stearin and palmitin are solids at ordinary temperatures, the melting point of stearin being from 123° to 157° Fahrenheit, and of palmitin a little less. Pure olein is a liquid at ordinary temperatures, and becomes hard at something below 40° Fahrenheit. Tallow oil is largely olein mixed, however, with more or less of palmitin and stearin. Each of these three chemical bodies consists of a characteristic acid chemically combined with glycerine, the stearin being stearic acid combined with glycerine, the palmitin, palmitic acid, and the olein, oleic acid combined with glycerine. It is, perhaps, more correct to say that when stearine, palmitin, or olein breaks up, stearic, palmitic, or oleic acid and glycerine are formed, water being absorbed in the process. In other words, stearin is stearic acid combined with glycerine, minus the elements of water, the water separating when the combination takes place. The point which we want to make is that these neutral fatty bodies contain an acid. The glycerine is a small percentage of the total weight of the tallow.

When the fat exists in the animal, at least if the animal is in a healthy condition, the three principal constituents of the tallow are, as stated above, simply neutral fatty bodies, enclosed in little membranous sacs in the fat tissues. In order to secure the tallow, and separate it from the tissues, heat alone is at present made use of—so far as our knowledge goes, at least. It is commonly believed that dilute sulphuric acid is made use of by many country butchers, to help in separating the fat from the tissue, but in our experience we have never seen any evidence that this method was practised. Generally the fat is thrown into either open kettles along with a very small amount of water, and heat applied, or it may be put in a closed vessel, and the heat communicated to the fat by means of steam pipes inside. In either case the same result follows, namely, the membranous tissues are ruptured and shrivel, and allow the melted fat to separate. At the end of the operation both the water added and the water contained in the tissue has disappeared, and the tissue has shriveled to be a very small proportion of the total mass. These shriveled bits of tissues are known commonly as "cracklings." The tallow is separated from the cracklings by straining and pressure, and is usually marketed in barrels containing about 350 to 380 lbs. each. If these operations are performed in the proper way, and under proper conditions, a tallow results which is almost neutral, as will be readily understood, being simply a mixture of the three neutral bodies above mentioned. In practice, however, it is excessively difficult to secure tallow as it was in the animal—a mixture of neutral bodies. Almost all commercial tallow, when examined in the proper way, shows the presence of more or less free acid, and this acid may vary in amount, from possibly 0.50 per cent. up to as high as 5.00 or 6.00 or 10 00 per cent. of the total weight of the tallow.

The acid just referred to is, so far as known, either one of the three acids which are characteristic of stearin, palmitin, and oleine, or mixtures of them. It is difficult to say which one, if either, predominates. We, of course, are speaking in a general way, and ignore the very small amounts of characteristic volatile fat acids which may be in the tallow. The explanation of this free acid in tallow seems to be that from some cause or causes, the glycerine is separated from the neutral bodies of which the tallow is composed. Experiments have been made by determining the amount of free acid under various conditions, and the following causes are believed to be prominent in increasing the amount of free acid in tallow:

First. If the fat is allowed to stand some hours or days before rendering, especially in warm weather, the amount of free acid will be great. This is, perhaps, very easily accounted for by our common knowledge, namely, that after death decomposition immediately sets in, and, so far as known, the first step in the decomposition of tallow is the separation of the fat acid from the glycerine. Whatever the explanation, definite experiments show that if the fat is rendered within, say, three or four hours after the animal is killed, attention being given to the conditions which follow, the amount of free acid may not exceed 0.50 per cent., even in warm weather. Six hours will bring it up to 0.75 per cent., 24 hours to 1.00 or 2.00 per cent., and two or three days may give a tallow containing as high as 5.00 to 8.00 per cent. of free acid.

Second. High heats increase the amount of free acid. It is difficult to say just exactly why, but perhaps the tendency to saponification by means of the water in the tissues is increased by high temperatures, it being well known that the glycerine in fat acids can be completely separated by water if a high temperature and pressure are employed.

Third. The amount of free acid in the tallow is increased when the rendering is done in closed vessels. This has been demonstrated by positive comparative experiments. Tests of tallow rendered in the same apparatus, in the one case the vessel being closed, and in the other the cover being left off, all the other conditions being exactly the same, showed that the tallow rendered in the closed vessel contained the largest amount of free acid. These experiments were made in the steam-jacketed apparatus used in one of the large abattoirs in Philadelphia. This is accounted for in the same way as in the previous case, namely, by the tendency to water saponification in the closed vessel. Those making tallow to be used as a cylinder lubricant, in which the amount of free acid is desired to be as low as possible, will therefore find it greatly to their advantage to render the tallow as soon as possible after the animal is killed, to avoid high heats, and to do the rendering in open vessels. If proper care is exercised in all of these respects, a commercial article can be made which will contain as low as 1.00 per cent. of free acid the year round.

It will be observed that considerable stress has thus far

been laid on the question of acid in tallow; the reason for this we will now attempt to make clear.

We are so accustomed to regard fats or greases of any kind as an antidote to corrosion, that it may seem singular to state that tallow under certain conditions may be extremely corrosive to iron. As stated in the first article of this series, one of the first questions investigated in the laboratory at Altoona was to find out why the valves and steam chests corroded so badly. It was not at all uncommon to find a valve, which had been in service not over a year, so eaten through under the valve yoke, that live steam from the steam chest would blow through into the exhaust. Also on removing the steam chest the contact between the steam-chest and the top of the cylinder was frequently found badly corroded, and a collection of blackish material always found. It was first thought that the tallow might contain sulphuric acid, introduced during the rendering, as above described. Careful examination of the black material did not show the presence of sulphates, and consequently this theory had to be abandoned. The steam was next charged with the crime, the well-known corrosion of surface condensers in marine engineering being supposed to be a parallel case. On this supposition, however, it was difficult to see why the corrosion should be so largely confined to the steam chest. The dry-pipes and the branch-pipes had equally the effect of the steam, but in no case was the same characteristic corrosion observed. During all this time the thought was prominent, as above stated, that tallow protected the metal surfaces from corrosion, and accordingly the other hypotheses were exhausted before thinking to take hold of the tallow. This view was strengthened by the fact that the best chemical literature at our disposal did not mention any salts of iron formed by the combination of the fat acids characteristic of tallow with iron. Watt's *Dictionary of Chemistry* gave descriptions of stearates and oleates of copper and other metals, but was silent on the corresponding salts of iron. Accordingly, a definite experiment was made by heating cast-iron borings with samples of stearic, palmitic, and oleic acids, the temperature maintained being that of the ordinary locomotive cylinder. Chemical action began before the temperature of the steam cylinder was reached, and continued in the experiment under consideration, as long as the metal and acid were allowed to remain in contact. The action of the acid on the iron produced a brown-looking stearate, palmitate, or oleate of iron. Corresponding experiments were made with tallow containing various amounts of free acid, and in every case the action of the acid on the iron was evidenced both by the formation of the brown salts above mentioned, and by the loss of weight of the iron borings, when separated from the products of the action. No special study was made of these fat acid salts of iron, the point which we were after, namely, whether the fat acids characteristic of tallow act on iron, being demonstrated. The reason why the products of the action of the tallow on the iron, which are found in the steam chests, are black instead of brown, is apparently due to an admixture of dirt, bits of cinder, etc.

This fact being established, the more important question of providing a remedy came into prominence. Obviously, the most natural remedy that would occur would be simply to neutralize the fat acid of the tallow with some alkali. We found this method already in practice by some of the so-called tallow refiners who were making cylinder tallow for the market. Rather inferior tallow of strong odor, and containing large amounts of free acid, was treated in some of the refineries with caustic soda. The soda and the free acid combined, forming, as is well known, common hard soap, and, of course, if the proportions were right, the amount of free acid in the tallow was entirely neutralized. The resulting cylinder lubricant was therefore a mixture of soap and tallow. This seemed like a very reasonable procedure, and it only remained to prove whether this resulting mixture was injurious to the metal. Positive experiments, quite to our astonishment, showed that the mixture of soap and tallow acted on the iron fully as rapidly, if not more so, than the free acid alone. These experiments were repeated many times, and always with the same result. Very pure tallow, containing almost no free acid, was heated up with iron borings to the proper temperature. If the amount of acid is as small as 0.50 per cent. the action is very slight, apparently due to the fact that there is so small an amount of acid and so large an amount of tallow. On dropping into this mixture a small piece of hard soap the action was increased quite largely, and as the result of all our experimentation, it was concluded that this remedy was worse than the disease. It is, perhaps, difficult to account for this behavior of a mixture of soap and tallow. The most reasonable explanation that we could suggest was that the soda of the soap gives up its acid to the iron, and by so doing is set free in condition to attack some of the tallow, and that this action goes on, of course, as long as either the iron or unsaponified tallow remain.

The experiments in attempting to neutralize the free acid resulted so disastrously that no further experiments were made in this line. It is possible that some base might be found which would not interchange with the iron in the tallow, but we did not carry on any experiments in this line further, except to attempt to combine glycerine with the free acid of the tallow, our reasoning being, that if we could restore the tallow to its neutral condition, by giving it back the glycerine which it had lost, it would be a satisfactory material. These experiments did not result in anything satisfactory, as although the reaction is a possible one, yet the conditions under which glycerine combines with free fat acid are somewhat difficult to control.

The attempts to neutralize the acid not succeeding as a practical measure, it was finally decided to attempt to obtain from the market a tallow containing the least possible amount of free acid, and the conditions leading to the formation of free acid in commercial tallow, as previously described, were somewhat studied. Early in the work on tallow a method of determining the amount of free acid in tallow was found to be a desideratum. The method employed is based on the fact that the free acids of tallow are quite soluble in ordinary alcohol, while the tallow itself is only slightly soluble. After a number of modifications and changes, the method finally adopted is given below, as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Method of Determining Free Acids in Oils and Tallow.

I.—Materials Required.

½ dozen 4-ounce sample bottles.

3 10 cubic centimeter pipettes, or, if desired, a balance weighing milligrams.

1 30 C. C. burette, graduated to tenths [burette-holder if desired], with pinch cock and delivery tube.

2 oz. alcoholic solution of turmeric.

2 qts. 95 per cent. alcohol, to which ½ oz. dry carbonate of soda has been added and thoroughly shaken.

1 qt. caustic potash solution, of such strength that 31½ cubic centimeters exactly neutralizes 5 cubic centimeters of a mixture of sulphuric acid and water, which contains 49 milligrams H_2SO_4 per cubic centimeter.

II.—Operation.

Take about two ounces of the clear alcohol and add a few drops of the turmeric solution, which should color the alcohol red, warm to about 150° Fahrenheit, then add 8.9 grams of the oil to be tested and shake thoroughly. The color of the solution changes to yellow. Fill the burette to the top of the graduation with caustic potash solution, and then run this solution from the burette into the bottle, little at a time, with frequent shaking, until the color changes to red again. The red color must remain after the last thorough shaking. Now read off how many cubic centimeters and tenths of the caustic potash solution have been used, and this figure shows whether the material meets specifications or not.

To determine the free acid in tallow, everything is done exactly as above described, except that the tallow is melted before it is added to the alcohol.

Ten cubic centimeters of extra lard oil, at ordinary temperatures, and the same amount of melted tallow at 100° Fahrenheit, weigh almost exactly 8.9 grams. In ordinary work, therefore, it will probably not be necessary to weigh the oil or tallow. Measurement with a 10-cubic centimeter pipette, will usually be sufficiently accurate, provided the pipette is warmed to about 250° Fahrenheit, and allowed to drain, the last drops being

blown out. In case of dispute, however, the balance must be used.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., February 16, 1889.

With regard to above circular it may be explained that the dry carbonate of soda is added to the ordinary commercial alcohol, because almost all commercial alcohol contains small amounts of acid, probably acetic, and, as will be readily understood, this acid would be counted as fat acid in the tallow if it was not neutralized. The addition of the small amount of carbonate of soda obviates this difficulty. The caustic potash solution required can be obtained in the market from any good dealer in chemical supplies. The turmeric solution is simply an indicator, it being well known that when turmeric solution is acid the color is yellow, and when alkaline it changes to a bright red. The use of phenol-phthalein as an indicator, does not give the same results as turmeric, when used with fats which have undergone considerable decomposition. No investigation has been made as to why this is true, nor are we sure which indicator gives the most accurate results.

The method used will doubtless be clearly understood. The fat acid being dissolved in the alcohol, the addition of the caustic potash solution combines with it, forming potash soap, which remains dissolved in the alcohol. When all the acid has been saturated with potash the color of the solution changes to red and the amount of acid is known from the amount of potash solution required. At first we were accustomed to give the results of free acid in percentages by weight, but in view of the fact that there may be any one, or mixtures of three different fat acids present, which acids differ in molecular weight, this method does not give quite accurate results, and was accordingly abandoned. The acceptance or rejection of tallow or oils in which the acid is determined, is now based upon the amount of standard alkali required to neutralize the acid. The limiting figures given in the specifications for tallow below do not differ far from 1.50 per cent. by weight of free acid in the tallow.

As the result of the whole study of this subject, including the method of determining free acid, and the conditions which lead to the formation of free acid in commercial tallow, as already described, specifications were prepared, and an attempt made to secure tallow in accordance with them. As has proven true in almost every case of new specifications issued by the Pennsylvania Railroad Company, during the last 14 years, considerable difficulty was experienced at first in getting material that would fill the requirements. Those who were rendering tallow had not been accustomed to have any careful examination of their product made, and many of them were very careless indeed. During the first six or eight months after the specifications were issued, it was found excessively difficult to get tallow enough, that would fill requirements, to supply the road. Gradually, however, as the manufacturers have learned to treat the material better, and especially to render the tallow quickly after killing the animal, the difficulties have disappeared, and for a long time very few rejections of tallow have taken place. The specifications first issued were revised from time to time as new information was obtained. The copy given below represents the specifications now in force. It is gratifying to be able to state, that although the specifications do not give a tallow for use in steam cylinders which entirely obviates corrosion, as above described, the first issue of tallow specifications was followed by a large diminution in the replacing of valves. After the specifications had been in force nearly two years the different Master Mechanics of the road were requested to state how the valves were behaving compared with the two years previous, without knowing what this information was desired for. In every case the statement came back that there was not as much trouble with corrosion of valves as had previously been experienced. The experience of the past six or eight years has confirmed this view, and it is, perhaps, not too much to say that from being a very annoying source of trouble, the repair of valves has diminished to a very insignificant item.

It is not hoped, however, that the specifications for tallow will ever entirely prevent the difficulty. As long as the tallow contains any free acid there will be some corrosion. Mixing high fire-test petroleum with tallow, as has been done in many cases for cylinder lubricant, is advantageous in diminishing the amount of free acid in the mixture. As already stated, the use of sight-feed lubricators, which use an oil containing very small amounts of any fatty acid, and which diminish largely the amount of lubricant used, will, undoubtedly, sooner or later, make any serious difficulty of valve or steam-chest corrosion a thing of the past. The present tallow specifications are as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Tallow.

Tallow for use in locomotive cylinders should contain the least possible amount of free acid, and should, at the same time, be as free as possible from dirt, *cracklings*, and fiber. In order to secure such tallow the following specifications have been adopted:

1. Tallow which, on inspection, is found to contain dirt or *cracklings* disseminated through it, or in streaks, or which has a layer of dirt or *cracklings* in the bottom of the barrel more than an eighth of an inch thick, will be rejected.

2. Tallow containing more free acid than is neutralized by three cubic centimeters of standard alkali will be rejected. The standard alkali, and directions for determining free acid are given in the circular, "Method of Determining Free Acids in Oils and Tallow," which will be furnished on application.

3. Tallow containing soap, or other substances not properly belonging to tallow, will be rejected.

To persons furnishing tallow, who may not have appliances for determining the amount of free acid in tallow, it may be said, that if the fat is rendered within twelve (12) hours from the time the animal is killed, using a temperature of not more than 225° to 250° Fahrenheit during the rendering, it is believed that the free acid in the tallow will be less than amount specified above. In very warm weather it may be necessary to render the fat in less than twelve (12) hours after the animal is killed.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., January 24, 1883.

The reason for each of the requirements in above specifications are, perhaps, all sufficiently evident from what has preceded. It is often found that tallow received from the country butchers contains rather large amounts of cracklings in a fine state of division. This results from using severe pressure in separating the tallow from the cracklings. Of course this material is inferior, and it is necessary to put a limit on the amount received. The examination of tallow, for soap and other impurities, is usually made by burning off the tallow, the soda of the soap remaining behind. Our experience for several years now indicates that there is very little attempt made in the market at present to remove the free acid by neutralization. The ordinary adulterations of tallow in the market are the addition of makeweights, consisting of soapstone, tripoli, or other substances of similar nature, and the admixture with the tallow of other fatty bodies or oils. In our experience it is very rare that a makeweight of any kind is added. If a barrel of tallow weighs over 380 lbs., exclusive of the barrel, it is a suspicious circumstance. Of course the amount of makeweight, if it is mineral matter, can be determined by burning the tallow and weighing the residue, or if soap is absent, by dissolving out the fat in ether or gasolene and weighing the residue.

Quite early in our work on tallow we found serious adulteration arising from the addition of petroleum products to the tallow. In one case no less than 20 per cent. of the weight of the tallow as received, was simply what is known in the market at present as paraffine oil, and what was known at that time as neutral oil. Nearly half of the oil added to the tallow became a vapor at the temperature of the steam cylinders, and, consequently, was worthless for lubrication. In addition to this, the oil cost in the market at that time three or four cents per pound, while the tallow was being sold at 11 cents per pound. This kind of adulteration is very rarely attempted at present, and is readily

detected both by the change of color of the tallow, if any of the cheaper grades of petroleum are used, and by a quantitative saponification by well-known chemical methods, if any white non-saponifiable substance is the adulterant.

A very peculiar treatment of tallow arose in our experience some years ago, consisting in this: On a certain railroad, to which a certain dealer was furnishing tallow, the little bits of the ends of the candles used in car lighting were sold to the dealer. He, very innocently, as is believed, melted up these bits of candles, added them to the tallow, and then sold the tallow to the railroad company, to be used as cylinder lubricant. This, of course, would cause those who are well informed on the subject to smile, since the ordinary car candle is pure and simple stearic acid, as near as it can be obtained pure in a commercial process, and in reality the dealer was adding to the tallow what the chemist had for some time been studying how to exclude from it. An examination made of several samples of this tallow showed free acid as high as 15.00 to 20.00 per cent., which is what we would expect. There was no attempt at concealment in this case; indeed, the practice was well known to the officers of the road, and it could hardly be classed as an adulteration, but as, rather, one of those cases which show the value of a little chemical knowledge in railroad operation. It is hardly necessary to add that the practice was abandoned as soon as the free acid determinations were made.

As stated at the outset, the use of tallow as cylinder lubricant is largely diminishing, and it is probable that within a few years its use will disappear almost entirely. For the benefit of those who are gradually going out of the use of tallow, it may, perhaps, be stated, that if the change is made suddenly from tallow to any of the well-known cylinder lubricants, very serious difficulties are apt to result. The reason for this is that most of the cylinder lubricants of the market consist largely of high fire-test petroleum, which petroleum is a solvent for the binding material of the black substance which, as has been previously described, is contained in the cavities of the valve, and around the edges where the steam chest joins to the cylinder, and also to the steam chest lid. The dissolving out of this substance sets free a large amount of grit and other material which gets between the surfaces and increases the friction enormously. An attempt to use petroleum alone as a cylinder lubricant on engines which had previously been using tallow, might result in breaking the rocker-shafts, and would certainly seriously strain the valve gear. This difficulty can be avoided if the change from tallow to cylinder lubricant is made gradually. Mix with the cylinder lubricant at least one-half extra lard oil for the first month, and gradually diminish the amount of lard oil from month to month. This subject will be referred to again under the head of Cylinder Lubricant.

(TO BE CONTINUED.)

THE NEW TORCY RESERVOIR.

THE great works undertaken in 1881 by the French Government on the Canal du Centre had for their object the enlargement of the cross-section of the canal and the lengthening of the locks. As a consequence it became necessary to increase the supply of water for the canal, and for that purpose a new reservoir has been constructed at Torcy, in the neighborhood of the great steel works of Creusot. This work was begun in the year 1883 and was finally completed and the reservoir filled in July, 1888. To distinguish it from the old reservoir near by, it is called the New Torcy Reservoir. It is situated a little over three miles from the main line of the canal, and the dam is near the village of Torcy. In the accompanying illustrations, fig. 1 is a map showing the position and plan of the reservoir.

The bottom of the reservoir is principally red sandstone, a rock which underlies much of the ground in the vicinity. The surface overflowed is about 412 acres; the reservoir itself is 9.32 miles in circumference; the greatest depth 47½ ft., and the storage capacity 309,600,000 cub. ft. With this assistance the supply of water for the summit level of the canal will be about doubled in the dryest season.

At one end of the dam a channel 39.3 ft. wide is provided for overflowing water. At the end of the dam also a watchman's house and storehouse are erected.

The dam itself, which at both ends is strongly anchored to the hill-side, is built of well-mixed clay and sand well rammed together, the mixture being about 66 per cent. of sand and 34 per cent. of clay. Its total length is 1,432 ft.; width at the top, 8.04 ft.; at the bottom, in the deepest part, 173.5 ft.; the greatest height is 43.5 ft., and the cubic contents of the dam are about 168,700 cub. yds. The slope of the dam on the water side is faced with masonry work 1.64 ft. thick, which is built upon a bed of broken stone and concrete and which rise, as shown in fig. 2, at an angle of 45° in steps 4.92 ft. in height broken by flat berms or treads 2.95 ft. in width. The outer side of the dam, which is built with a slope of 1 : 2.73, is not faced, but to a height of some 16.5 ft. from the bottom is

Fig. 1.

planted with acacias. The top of the dam, which is 5.9 ft. above the highest level of the water, is faced with stone, which is a continuation of the masonry work on the inner side, and across the top runs a wall 3.94 ft. in height.

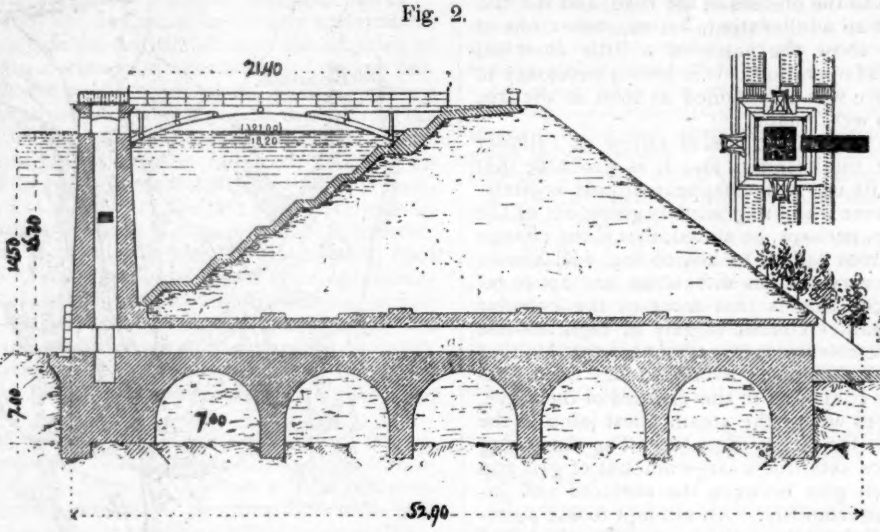
On the water side, for the whole length of the dam, runs a bed of masonry about 5 ft. in depth upon which the bottom of the facing masonry rests, and which is carried 3.28 ft. below the surface of the ground. Before building this masonry, or beginning the construction of the dam, the ground was carefully cleared off to the rock, and in addition two trenches 3.28 ft. in depth were carried the whole length of the dam in order to provide a better connection between the ground and the dam itself.

The clay for the dam was laid in layers 4 in. thick, and then rolled down hard with steam and horse rollers. In building it was found that with a steam roller weighing about 5 tons, about 650 cub. yds. could be rolled in a day's work. The cost of putting in place and rolling down the material for the dam was 3.35 cents per cubic yard.

The bottom of the waste canal is 2.3 ft. below the usual level of the water. This canal is closed by wooden gates, which open automatically when the water rises above a certain level. The out-take, or channel, through which the water is drawn from the reservoir, is through a water tower, which is built up from the base of the dam on the water side, and which is also used as an overflow or outlet for

the water when it rises above the average level. Fig. 2 shows a section of the dam through this tower and the channel, the outer end of which opens into the feeder through which the water is taken to the canal. It will be seen that the masonry of the tower and of the channel are continuous. The openings into the tower are closed by iron gates, which are worked from the platform at the top. The vertical shaft in the tower is 4.92 ft. in diameter and ends in a well 6.56 ft. in depth, which is always full of water in order to prevent any shock or injury to the masonry from the falling body of water in the tower. The openings through which water is admitted are three in number, 13.75 ft. apart, each opening being 15.7 × 31.6 in. in size. These are closed by cylindrical iron gates made on a new plan, and opening in a curve at an angle of 45° to the axis of the tower. A fourth gate of similar construction is placed inside the tower at the bottom; this has an opening 70.9 × 43.3 in. in size into the outlet canal. This is closed by an iron gate carried on a little carriage having four rollers, which runs upon tracks made for the purpose in the masonry. This gate is kept tight by packing-plates of thick rubber. Careful calculations were made in building this gate, and it has been so proportioned that it can be easily worked from the platform at the top of the tower. Since the reservoir has been in use the arrangement has worked very satisfactorily.

Fig. 2.



SECTION OF DAM, NEW TORCY RESERVOIR.

In building this reservoir several auxiliary works were required. It was necessary to make a new location for the railroad line from Nevers to Chagny and for the line connecting with the Creusot Works, and it was also necessary to relocate several roads. The total cost of the reservoir was about $447,000, of which $107,000 was spent for the dam; $116,000 in relocating the railroads and the roads, and the remainder for land and other expenses. The total cost, estimated by storage capacity of water, was about 0.13 cent per cub. ft.

The plans were made by Chief Engineer Fontaine and Engineer Desmur, who also superintended its construction.

UNITED STATES NAVAL PROGRESS.

PERHAPS the present condition and needs of our Navy cannot be better shown than by the very interesting report of the Secretary of the Navy, recently submitted to Congress. Accordingly some extracts from that report are given below:

PRESENT CONDITION OF THE NAVY.

The effective force of the United States Navy, when all the ships now authorized are completed, excluding those which, by the process of decay and the operation of law, will by that date have been condemned, will comprise 11 armored vessels, of which only 3 are designed for fighting at sea, and 31 unarmored vessels, making a total of 42.

The following statement shows the number of war-vessels on the effective list of the principal foreign powers, built, building, or projected at the present time, and exclusive of sailing and practice ships:

COUNTRY	ARMORED.	UNARMORED.	TOTAL.
England	76	291	367
France	57	203	260
Russia	49	119	168
Germany	40	65	105
Holland	24	70	94
Spain	12	78	90
Italy	19	67	86
Turkey	15	66	81
China	7	66	73
Sweden and Norway	20	44	64
Austria	12	44	56

The table shows that, even when the present building programme is completed, the United States cannot take rank as a naval power.

The purpose for which the United States maintains a navy is not conquest, but defense. For reasons of economy and public policy the force should be as small as is consistent with this object. But it appears from the above comparison that, with all the additions authorized by the legislation of the last seven years, the country, as far as its capacity for defense is concerned, will be absolutely at the mercy of States having less than one-tenth of its population, one-thirtieth of its wealth, and one-hundredth of its area. While the element of defensive strength is thus clearly deficient, the vulnerable points open to an enemy's attack, and the interests liable at all times to injury, are numerous and important. A coast line of 13,000 miles, upon which are situated more than 20 great centers of population, wealth, and commercial activity, wholly unprotected against modern weapons, affords an inviting object of attack, with a wide range of choice as to the points to be selected. Any one of the powers named could, without serious difficulty, even after the completion of our fleet as now authorized, secure in a single raid upon our coast an amount of money sufficient to meet the expenses of a naval war; an amount one-half of which, if judiciously expended over a series of years, would be sufficient to afford this country a guarantee of perpetual peace.

The defense of the United States absolutely requires the creation of a fighting force. So far the increase has been mainly in the direction of unarmored cruisers. These vessels, while useful in deterring commercial States from aggression and as an auxiliary to secure celerity and efficiency in larger operations, do not constitute a fighting force, even when it is intended exclusively for defense. To meet the attacks of ironclads, ironclads are indispensable. To carry on even a defensive war with any hope of

success we must have armored battle-ships. The capture or destruction of two or three dozen or two or three score of merchant vessels is not going to prevent a fleet of iron-clads from shelling our cities or exacting as the price of exemption a contribution that would pay for their lost merchantmen ten times over. We must do more than this. We must have the force to raise blockades, which are almost as disastrous to commercial cities as bombardment. We must have a fleet of battle-ships that will beat off the enemy's fleet on its approach, for it is not to be tolerated that the United States, with its population, its revenue, and its trade, is to submit to attack upon the threshold of its harbors. Finally, we must be able to divert an enemy's force from our coast by threatening his own, for a war, though defensive in principle, may be conducted most effectively by being offensive in its operations.

If the country is to have a navy at all it should have one that is sufficient for the complete and ample protection of its coast in time of war. If we are to stop short of this we might better stop where we are, and abandon all claim to influence and control upon the sea. It is idle to spend our money in building small, slow-going steamers, that are unnecessary in peace and useless for war. It is little better than a repetition of the mistaken policy that prevailed in our early history of building gunboats that were laid up or sold as soon as war broke out. The country needs a navy that will exempt it from war, but the only navy that will accomplish this is a navy that can wage war.

THE NEW CRUISERS.

The new cruisers are eight in number—the *Chicago, Boston, Atlanta*, and *Dolphin*, contracted for in 1883, and the *Baltimore, Charleston, Yorktown*, and *Petrel*, contracted for in 1886 and 1887.

At the very time when the first cruisers were being designed the department took steps to supply its want of experience by the systematic acquisition of information as to naval progress abroad. The establishment of the Office of Naval Intelligence and the assignment of naval attachés to duty in Europe, both of which measures date from 1882, have been of incalculable assistance in the work of reconstruction, and it is proper to refer especially to the untiring and successful efforts of Commander F. E. Chadwick, the first attaché sent out, whose extraordinary ability and judgment during six years of difficult service in England and on the Continent have had a lasting influence upon naval development in this country. The results subsequently obtained have shown the wisdom of the policy adopted at the outset.

The net results of the Department's operations for the last seven years are more than satisfactory. The assaults made, with more audacity than judgment, upon the four experimental cruisers of 1882 have been met successfully by the performance of the vessels, and all doubts of their efficiency, if such doubts ever really existed, are laid at rest forever; while the four cruisers of 1886, assuming that the *Petrel* will eventually come up to the mark, in their advance over their predecessors, prove that both designers and constructors have kept themselves abreast of the extraordinary development in shipbuilding since the earlier cruisers were laid down, and have taken full advantage of the information and experience which they were enabled to acquire through the measures adopted at that time by the Navy Department.

ARMORED BATTLE-SHIPS.

To stop now in the work of reconstruction is to abandon everything we have gained. We have proved that at a time when war-ship construction had seemed almost a lost art in this country, American mechanics could create it anew and place the United States where it was 70 years ago, when the vessels of its navy were the best of their class afloat. We have fostered and developed a branch of industry in America which may, if kept up, attract to itself no inconsiderable share of the profits that now go to shipbuilders abroad. We have secured for our navy a certain number of excellent and useful vessels of the unprotected cruiser type at a fair and reasonable cost. We have thus laid a solid foundation. But we must not for a moment deceive ourselves by supposing that we have an effective navy. We have two distinct and widely separated ocean frontiers to protect, and there is only one way in which they can be protected—namely, by two separate fleets of armored battle-ships, with coast defense ships suitably distributed to cover the most exposed localities.

Of the great cities on the Atlantic, and of the long stretch of unprotected coast on the Gulf, from Key West to the Rio Grande, which is faced by the territorial possessions of a multitude of foreign States, it is hardly necessary to speak at length. On the Pacific Coast there are large and growing interests of vital importance, not only to that immediate neighborhood, but to the whole country, throughout its length and breadth. Among the enterprising and rapidly-growing cities which form the bulwarks of our commercial prosperity in that quarter, there are some, like Tacoma and Seattle, which it is physically impossible to protect by any land fortifications. To abandon these cities, defensible only by the navy, to the possible attacks of an enemy, and to subject to needless risk this coast and the vast region which it borders—a region second in importance to no other part of the United States—is to be guilty of an almost criminal negligence.

The necessities of our vulnerable position, therefore, demand the immediate creation of two fleets of battle-ships, of which eight should be assigned to the Pacific and 12 to the Atlantic and Gulf. They must be the best of their class in four leading characteristics—armament, armor, structural strength, and speed. The last is nearly as essential to the battle-ship as it is to the cruiser. It may safely be assumed that, other things being equal, the battle-ship of the highest speed will, as a rule, be the victor in action, for she can choose her position and keep the enemy at a disadvantage. Not only must the speed of our battle-ships be high, but it must be uniformly high, for the speed of the fleet is regulated by that of the slowest vessel.

In addition to the battle-ships, the situation of the country requires at least 20 vessels for coast and harbor defense. These vessels, although restricted in their range of effectiveness, are necessary components of a naval force which has a sea-coast to defend. Their employment as floating fortresses requires that they should have a powerful battery and the heaviest of armor, combined with moderate draft. At the present time eight vessels of this type are under construction, five of which are reconstructed monitors.

The one problem now before the Government, in the matter of a naval policy, is to get these 40 vessels built at the earliest possible moment. The steps necessary to their completion—legislation, design, and construction—cannot take less than five years in the case of each one. Unless the existing yards, public and private, are enlarged and restocked with plant, not more than eight could be built at one time, and the construction of the others would have to wait for the launching of the first. Using the utmost promptness, the ships most essential to efficient protection could not be supplied in less than 12 or 15 years.

It is, therefore, recommended that the construction of eight armored vessels be authorized at the coming session, and that they be of the type of battle-ships rather than of coast-defense ships; the former being more generally serviceable, and there being only three of them now in process of construction as against eight of the latter.

FAST CRUISERS.

In reference to fast cruisers, all modern experience goes to show that they are essential adjuncts of an armored fleet, and the proportion of three cruisers to one battle-ship is believed to be sound and reasonable. This would make the future navy consist of 20 battle-ships, 20 coast-defense ships, and 60 cruisers, or 100 vessels in all, which is believed to be a moderate estimate of the proper strength of the fleet. Of the 60 cruisers required, 31 are now built or authorized. For an increase in the number of cruisers, considered simply as auxiliaries to the fighting force of battle-ships, we may wisely wait until the latter are in process of construction. . . . . .

The naval policy of the United States cannot neglect to take account of the fleets of fast cruisers which foreign States maintain under the guise of passenger and mer-

chant steamers. They constitute an auxiliary navy, and must be reckoned as a part of the naval force of the governments maintaining them. It is difficult to imagine a more effective commerce destroyer than the steamship *City of Paris*, armed with a battery of rapid-firing guns. She can steam over 21 knots an hour, and can average 19.9 knots from land to land across the Atlantic. No man-of-war could overtake her; no merchantman could escape her. A fleet of such cruisers would sweep an enemy's commerce from the ocean. This fact is well understood in Europe, and States that are unprovided with a convertible merchant fleet are preparing to meet the possible emergency by partly-protected cruisers that are substantially as fast as the *City of Paris*. Of this type the *Piemonte* is the latest development, and others equally fast are now building.

Our deficiency should be supplied either by a line of fast merchantmen, constructed with special reference to use in time of war, which will enable the Government to avail itself of their services at critical moments, or we should build a fleet of at least five first-class cruisers of the very highest rate of speed, certainly not less than 22 knots. The displacement of these vessels should not be less than 4,000 tons. Even such a fleet will not supply the want of swift merchant steamers for coaling and transport service. Colliers and transports must alike be fast, for they cannot fight; and the collier can take no chances of capture, for she carries the life of the fleet.

In determining the size of the smaller type of cruisers, one point is settled: All steel cruisers must be large enough to admit of a double bottom. A vessel like the *Yorktown*, which has but ⅜ in. of steel on her bottom, could hardly escape sinking if she touched a rock, no matter how lightly. Such a ship must not strike. She cannot run any of the risks which the old-fashioned ships used to run every day with comparative safety, for a steel bottom will be penetrated where a wooden one would be merely scarred. Besides the *Yorktown* we have the *Concord*, the *Bennington*, and the three 2,000-ton cruisers (Nos. 9, 10 and 11), which are marked by this defect. It is not well to add to the number.

In reference to the gunboat class, any large increase in it must be condemned. This class is now represented by the *Petrel* and the two 1,000-ton vessels (gunboats Nos. 5 and 6). To make any considerable addition to it is consuming the revenues of the Government without any proportionate benefit. It is chasing the shadow and losing the substance. Such vessels add nothing to the real strength of a naval force. A cruiser to be useful must be fast enough to overtake any merchantman and to escape from any more powerful ship of war. These vessels have neither the strength to fight nor the speed to run away. A limited number of 1,000-ton vessels can be utilized in certain special kinds of service on foreign stations, and for this particular purpose it is recommended that three such vessels be constructed. Any larger increase at the present time would be injudicious and wasteful.

TORPEDO BOATS.

Apart from the want of battle-ships the most marked defect of the present fleet is in torpedo boats. The number of these boats owned by 15 foreign States is as follows:

COUNTRY.	TORPEDO BOATS.
England	207
France	191
Russia	138
Italy	128
Germany	98
Austria	60
Greece	51
Turkey	29
China	26
Denmark	22
Japan	21
Sweden and Norway	19
Holland	16
Spain	15
Brazil	15

The United States has one such boat under construction. This branch of defense cannot safely be neglected any longer. It is high time that steps should be taken to supply these essential constitutents of a naval force. I therefore recommend that the construction of at least five torpedo boats of the first and second classes, in suitable proportions, be authorized, as a beginning, at the coming session of Congress.

NAVAL RESERVE.

The question of the creation of a naval reserve demands the early attention of Congress. This reserve should be composed of ships, officers, and seamen. The numerical strength of our Army is not measured by the standing force, but by the trained militia behind it. The same should be true of the Navy. The necessity is even greater in this branch of the service, because a naval militia must have a special training to render it efficient in case of emergency, and it must be drawn from a limited portion of the population.

The subject has already received considerable attention, both in Congress and in the State Legislatures. Congress has as yet failed to pass any law on the subject, but the Legislatures of several States, taking the initiative, have made arrangements for the creation of a naval militia. In so far as these measures require the co-operation of the United States Government, I am heartily in favor of giving it. Where stationary vessels are desired for purposes of gunnery training, I recommend that the Department be authorized to furnish such vessels as are now laid up, unfit for sea service, to States making provision for a naval militia, upon their request. Authority should also be given for the issue of arms, and such legislation should be adopted by Congress as is necessary to give the new system vigor and efficiency.

NAVY YARDS.

On the broad question which arose in the case of the two 3,000-ton cruisers of the comparative advantages of the two systems of naval construction, the first in the Government yards, and the second by contract with private firms, the department is firmly of the opinion that the latter is the best method. It may reasonably be expected that as shipbuilding in America is gradually improved and cheapened, additional private business will be attracted to these growing establishments, until in time the world's market for ships will be divided between this country and Europe.

All these advantages are lost by a policy that confines the construction of vessels exclusively to the navy yards. Still it is advisable that the navy should build some of its ships. While the great majority of our new vessels should be constructed by private builders, the Government yards should also be utilized to a limited extent.

The only naval stations now in use as construction yards are Brooklyn, Norfolk, Mare Island, and Portsmouth, the last for wooden vessels only. The other navy yards were closed, as far as construction and repair were concerned, by order of the Secretary, June 23, 1883, under the provisions of the act of August 5, 1882.

The department having taken this action in pursuance of law, the yards referred to must remain closed until the law shall reopen them. At present there are building sites for eight ships at Brooklyn and Norfolk, and for three at Mare Island. Of the former five are now occupied. Provision has been made for supplying these yards with a working plant, which is now in part delivered. A further appropriation of $50,000 is required for tools at Brooklyn. The three construction yards will then have a working outfit. If additional facilities are needed to hasten the construction of the Navy, they may be provided either at Boston or League Island, each of which presents considerable advantages of situation.

At the Boston Navy Yard a modern plant for building steel vessels sufficient for work on an extensive scale can be set up at moderate cost. The League Island Yard has remained since its transfer to the Navy Department largely in an undeveloped state. It has fresh water in which to lay up iron and steel ships. In this last respect it stands alone, and this consideration is of itself sufficient to warrant its gradual improvement. The yard should,

therefore, be put in such order as to make it available at least for purposes of repair.

The suggestion that the naval station at Port Royal, S. C., be provided with a dry dock and other necessary facilities for docking vessels is heartily approved. The objects of a navy yard are threefold: it may be a construction yard, a repair yard, or a naval station, or all combined. For a new construction yard the Navy Department has no use. A repair yard in the Northwest will be necessary at some future time, and the time is not very far off. Vessels in those waters must not be under the necessity of going 2,000 miles to San Francisco and back to clean their bottoms or to have slight repairs made. The site for such a yard is unquestionably in Puget Sound, which has all the advantages of favorable position, great extent of navigable waters, freedom from dangers and from obstruction by ice, a temperate climate, a promise of extraordinary development, and great natural resources in coal, iron, and timber. A naval station there is needed now.

ORDNANCE.

The number of high-power steel cannon for the Navy completed to date includes 2 5-in., 48 6-in., 8 8-in., and 3 10-in. During the past year 21 6-in. guns have been finished at the Washington Navy Yard, three at the West Point Foundry, and three at the South Boston Iron Works. Besides these nine guns are in course of construction.

APPROPRIATIONS.

The estimates of the Department for the requirements of the ensuing year are $25,599,254. These include $16,212,754 for the maintenance, equipment, repairs, etc., and $9,386,500 for increase of the Navy, the latter amount to be distributed as follows: To the Bureau of Construction and Repair (new ships), $4,000,000; to the Bureau of Steam Engineering (new engines), $1,120,000; to the Bureau of Ordnance, $3,971,500 for new guns, $145,000 for the gun plant at the Washington Navy Yard, and $150,000 for the submarine torpedo-boat.

NAMES FOR NEW SHIPS.

It is recommended that the following rule be adopted for the naming of vessels: Battle-ships, after the States of the Union; cruisers, after the cities; coast defenders, armored, after important events or names connected with the history of the United States; coast defenders, unarmored, after rivers of the Union. Vessels of special classes should be given names appropriate to the service for which they are intended.

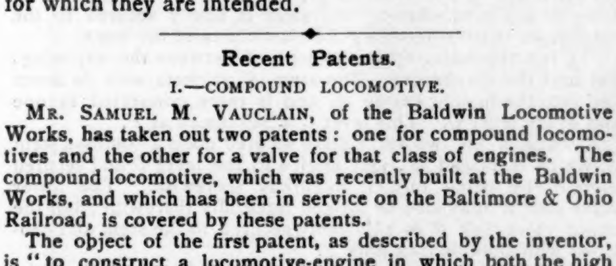
Recent Patents.

I.—COMPOUND LOCOMOTIVE.

MR. SAMUEL M. VAUCLAIN, of the Baldwin Locomotive Works, has taken out two patents: one for compound locomotives and the other for a valve for that class of engines. The compound locomotive, which was recently built at the Baldwin Works, and which has been in service on the Baltimore & Ohio Railroad, is covered by these patents.

The object of the first patent, as described by the inventor, is "to construct a locomotive-engine in which both the high and the low-pressure cylinders are on the same side of the locomotive, side by side, and connected to a common cross-head (as shown in figs. 1 and 2), so that an equal amount of power is delivered to each side of the engine; a further object being to so construct the parts that a locomotive of the single-acting

FIG. 1



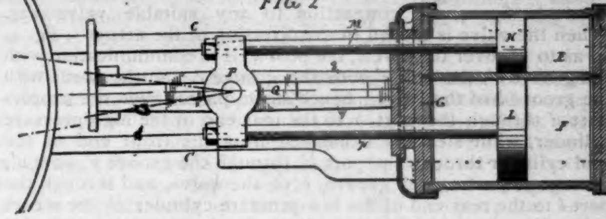
American type can be readily altered into a compound locomotive."

Fig. 1 is a skeleton side view of the engine and fig. 2 a longitudinal section of the cylinders, from which the construction will be readily understood.

The principal claim in this patent is the following:

"The within-described compound cylinder structure for locomotives, said compound structure comprising a portion on the outer side of the engine-frame and a portion on the inner side of said frame, the portion on the outer side containing the high and low-pressure cylinders, situated side by side, and the valve-chest structure for said cylinders, and the portion on the inner side containing the inlet and exhaust passages, which extend up to the smoke-box, so that the structure is capable of

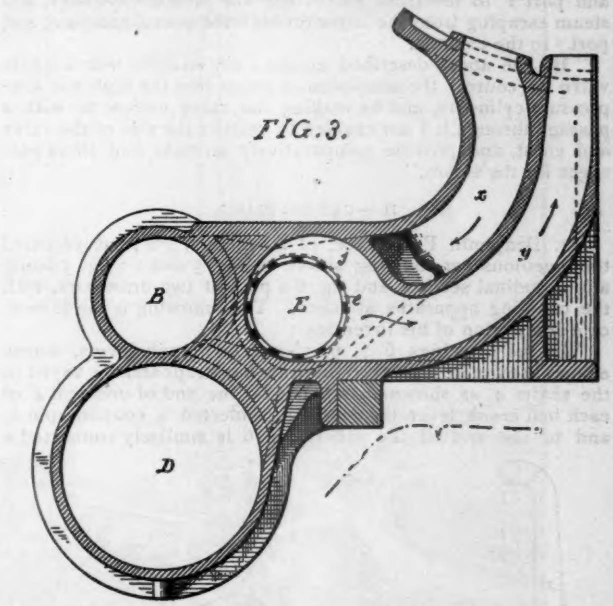
FIG. 2



being substituted for the usual single-cylinder structure of a locomotive without change of the adjacent structure, substantially as specified."

The object of the second invention, which is covered by the second patent, is to provide a compound engine with a single valve common to both the high and low-pressure cylinders, the

FIG. 3.

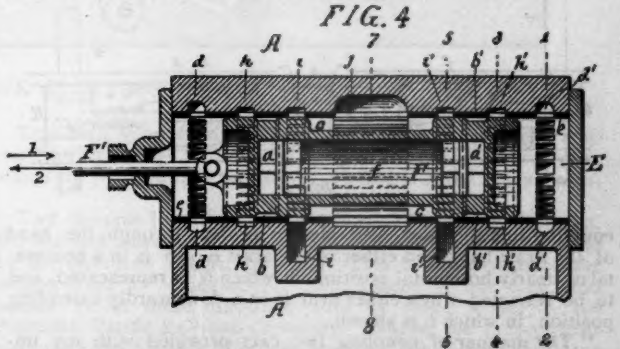


valve having been especially designed for use in connection with compound locomotive-engines, but being applicable to stationary or marine engines as well.

Fig. 3 is a transverse section through the cylinders, steam-chest and bed-casting, and fig. 4 a longitudinal section of the valve, which is thus described by the inventor:

"In the valve-chest E is a bushing e, slotted or perforated at the inlet and outlet ports, as shown, to permit the steam to enter and exhaust from the valve-chest.

FIG. 4



"F, fig. 4, is a hollow piston-valve having a high-pressure exhaust-passage f extending between openings a a' in said valve, said openings communicating with external grooves b b' in the periphery of the valve. The valve is also grooved externally at the center c, the grooves forming passages for the steam, as described hereinafter. The steam-supply ports d d'

communicate with the steam-passage x, fig. 3, these ports being situated at the extremes of the valve-chest, as shown in fig. 4.

"Ports h h' communicate with the opposite ends of the high-pressure cylinder, and serve alternately as induction and eduction ports for said high-pressure cylinder, i i' being the corresponding ports for the low-pressure cylinder, and j is the final exhaust-port communicating with the exhaust-passage y, as shown in fig. 3.

"A valve-rod F' is connected to the valve F, and passes through a stuffing-box in the head of the valve-chamber, as shown in fig. 4, for connection to any suitable valve-gear. When the valve is moved in the direction of the arrow 1, fig. 4, so as to uncover the port h, the port h' is in communication with the groove b', the port i' with the groove c, and the port i with the groove b of the valve; hence steam passes from the supply-port d through the port h to the rear end of the high-pressure cylinder, while steam is exhausted from the front end of the said cylinder through the port h', through the groove b', port a', passage f, port a, and groove b of the valve, and through the port i to the rear end of the low-pressure cylinder D, the steam exhausting from the front end of the low-pressure cylinder through the port i', groove c, and port j to the exhaust-passage y.

"When the valve is moved in the direction of the arrow 2, high-pressure steam from the supply-port d' passes through the port h' to the front end of the high-pressure cylinder, steam passing from the rear end of the same through the port h, valve, and port i' to the front end of the low-pressure cylinder, and steam escaping from the latter through the port i, groove c, and port j to the exhaust.

"By the above-described means I am enabled with a single valve to control the admission of steam into the high and low-pressure cylinders, and by making the valve hollow or with a passage through it I am enabled to restrict the size of the valve and chest, and provide comparatively straight and short passages for the steam."

II.—CAR-COUPLING.

Mr. Benjamin Follansbee, of Allegheny, Pa., has patented the ingenious car-coupling shown in figs. 5 and 6; fig. 5 being a longitudinal section, and fig. 6 a plan of two draw-bars, with the coupling apparatus attached. The following is the inventor's description of his invention:

"In the drawings 6 7, 6' 7' are bell-crank levers, whose elbows are situated between the draw-bar straps and are keyed to the shafts 4, as shown in fig. 2. To the end of one arm 4' of each bell-crank lever is pivotally connected a coupling-pin 8, and to the end of the other arm 6 is similarly connected a

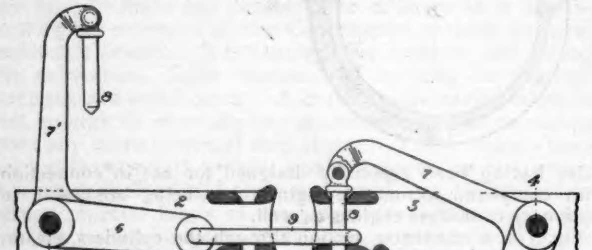


Fig. 5

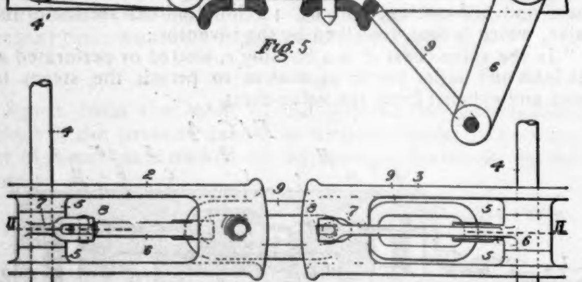


Fig. 6

coupling-link 9, which is adapted to project through the head of the draw-bar when either of the arms 6 or 6' is in a horizontal or nearly horizontal position, in which 6' is represented, and to be retracted when either arm is in a downwardly-extending position, in which 6 is shown.

"The manner of coupling two cars provided with my improvement is clearly shown in fig. 5. The arm 7' of the bell-crank of one draw-bar is elevated, and the arm 6' is therefore brought to a horizontal position, so as to project its coupling-link 9' through the draw-head and into the draw-head of the next car. The bell-crank lever of the other coupling is put into such position that the arm 7 is nearly horizontal, and the arm 6 extends downwardly, thus bringing the coupling-pin 8 through the pin-holes in the draw-head 3 and through the coupling-link of the draw-bar 2, and retracting the coupling-link 9 of the draw-bar 3 out of the path of the other coupling-link, the end of the link still, however, resting on and being supported by the head of the draw-bar.

"It is obvious that in coupling the cars the link of either car may be projected and the other link retracted, and that my improved coupler may be used in connecting the couplers of the ordinary link-and-pin form.

"For the purpose of operating the bell-crank levers of the couplers without making it necessary to enter the space between the cars, the shafts 4 and 4' are extended to the outside of the cars, and their ends are provided with cranks by which the shafts may be turned and the bell-crank levers may be put in the proper position to couple or uncouple the cars to which they are attached."

III.—PRESSURE-REGULATOR.

Mr. James F. McElroy, of Lansing, Mich., has patented a pressure-regulator which he says is particularly adapted for use in connection with steam-heating apparatus for railroad cars. It is shown in section by fig. 7, and is described as follows:

"The casing consists of a tubular portion A, provided at opposite ends with suitable pipe-connections B and C, and of a

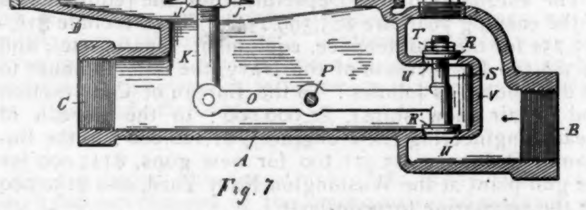


Fig. 7

diaphragm-valve casing D and D', in close proximity to the top of the tubular casing and connecting therewith. The upper portion or cover D' of this casing is connected with the lower portion D, with the edge of the diaphragm-disk E clamped between. The cover D' is provided with an upwardly-projecting boss F, which is screw-threaded to receive the hollow adjustment-nut G, which is locked in position by a jam-nut H. In the center of the diaphragm is secured by means of the nuts and washers J and J' the screw-threaded stem K. The washers are made of spherical shape, with corresponding spherical faces on the nuts, whereby the stem is firmly secured to the diaphragm without reducing the elastic area of the same.

"L is a regulating-spring interposed between the adjusting-nut and the diaphragm. The stem K projects with its lower end into the tubular casing A, and is there connected to one end of the lever O. This lever O is fulcrumed at P.

"R and R' are two valve-disks secured upon a common stem S, which is placed at right angles to the lever O and secured thereto, by being formed integrally therewith. The lower valve disk R' may also be formed integrally therewith; but the upper valve-disk R is adjustably secured to the stem and provided with suitable lock-nuts T.

"U and U' are the valve-ports, controlled by the valve-disks R and R', and these valve-ports are formed by a partition V, which divides the high-pressure side from the low-pressure side of the device. Below the valve R' and above the valve R the casing A is enlarged to form a free access of the steam to the valve-disks, and a screw-plug is secured in the casing above the valve R to afford access to the valve for the purpose of adjustment.

"In the absence of any steam-pressure the adjustment of the regulating-spring L is such as to keep the valve-ports U and U' normally open, and if steam is admitted through the inlet B it is free to enter through such ports into the low-pressure side of the device, which opens out underneath the diaphragm, and, acting against the same by its pressure, will distend the diaphragm against the action of the regulating-spring, and thereby, through its connection with the valve-stem K, the lever O, and valve-stem S, will absolutely control the position of the valves R and R' in relation to the ports, and should the pressure upon the diaphragm exceed a certain limit, according to the adjustment of the spring L, both valves will be closed upon their seats until the pressure on the diaphragm is relieved. Thus it will be seen that the amount of steam admitted into the low-pressure side depends entirely upon the tension of the diaphragm through the regulating-nut G, and any desired fixed

pressure, therefore, may be maintained on the low-pressure side, no matter what the pressure of steam is on the high-pressure side.

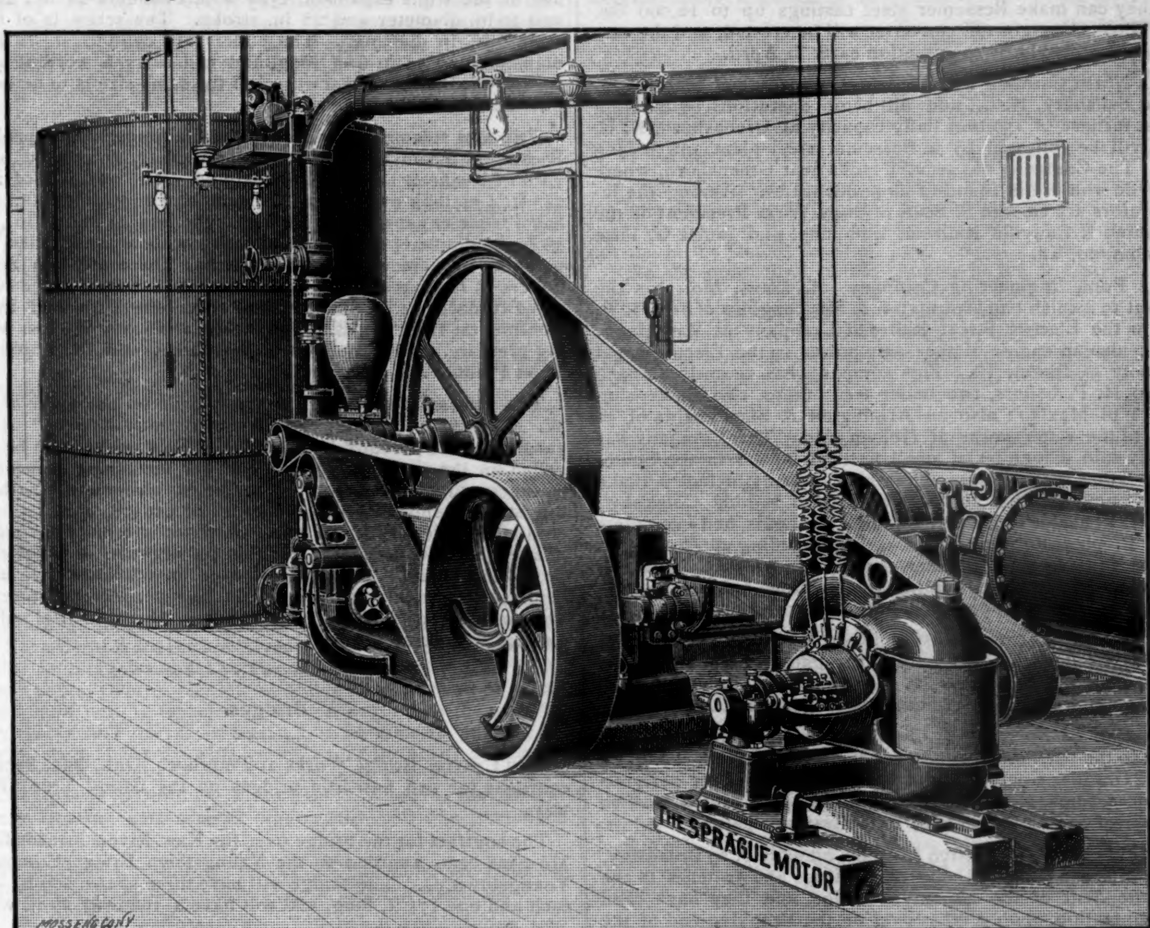
"The valves R and R' are balanced both on their high and low-pressure sides by making them both of the same area. To prevent too quick a motion of the diaphragm, I provide a small vent or pin-hole Y, through the cover D', which is covered with a screen to prevent dirt from entering."

An Electric Elevator Installation.

THE accompanying illustration shows a view of a recent installation of excellent design for an hydraulic elevator, which has been put in the building of the United Security, Trust & Safe Deposit Company in Philadelphia, by the Otis Elevator Company, of Yonkers, N. Y., and by Chadbourne, Hazleton & Company, of Philadelphia, who are agents in Pennsylvania for the Sprague Electric Railway & Motor Company of New York. When the elevator was first put in a gas-engine was used to supply the necessary power, but it did not prove satisfactory, and the Sprague motor was substituted. This is now giving perfect satisfaction, and is considered to be one of the best-running elevator plants in Philadelphia.

A notable point about the whole arrangement is that the minimum of space has been taken for every part of this installation. The pump was manufactured specially for this plant, and the arrangement for reduction of speed between the armature shaft and the pump is made in the compact manner shown. The motor operates the pump against the pressure in the tank, there being no overflow, and when the maximum pressure is reached the motor runs empty, automatically cutting down the amount of electric current taken from the line, so that only sufficient current is used to supply the energy necessary to keep the motor in revolution.

The illustration is made from a photograph taken directly from the plant, and shows the details of the installation very completely.



ELEVATOR WITH SPRAGUE ELECTRIC MOTOR.

Manufactures.

Manufacturing Notes.

THE steel plates and shapes for the armored ships *Maine* and *Texas*, now under construction at the New York and Norfolk Navy Yards, are to be furnished by Carnegie Brothers & Company, limited, and the Linden Steel Works in Pittsburgh, the contracts having been awarded to those firms.

AT the recent Exhibition in Pittsburgh a remarkable display of aluminum was made by the Pittsburgh Reduction Company, the exhibit including probably the largest amount of that metal ever shown at once. It included a number of small ingots weighing 5 lbs. each and aggregating in all about one ton in weight; one large ingot weighing 150 lbs. and a number of articles manufactured of the metal. The Company has been very successful in its production of aluminum so far, and the price of this metal in workable form has already fallen about one-half.

THE Bethlehem Iron Works at Bethlehem, Pa., have a contract for the steel to be used for the new 3,000-ton cruisers, which are to be built in the New York and Norfolk Navy Yards.

THE Bucyrus Foundry & Manufacturing Company, Bucyrus, O., has just taken a contract to build five large steam-shovels for the Northern Pacific Railroad. This is believed to be the largest order for steam-shovels ever placed at one time, and makes 11 of these machines sold by these works to the Northern Pacific Railroad Company. During the present year also, the Lake Shore & Michigan Southern has bought four large Bucyrus shovels. Other orders on hand include three large land-dredges to be used in constructing a canal at Bear Lake, Utah; three large steam-shovels to go to the iron-ore district on Lake Superior, to be used for handling iron ore from the stock piles; 13 steam-shovels for spring delivery, and several large dredges. The works are running overtime to fill orders.

THE Schoen Manufacturing Company, of Philadelphia, has increased its capital stock to $300,000, and is now engaged in building new works in Pittsburgh adjoining those of the Oliver Iron & Steel Company. The buildings are of iron and fire-proof, and will contain a complete forging plant on the hydraulic system, with a capacity for turning out from 40 to 50 tons per day. The Company's chief business is in the manufacture of articles in pressed steel for railroad equipment, such as center plates, stake pockets, etc. The President of the Company is C. T. Schoen, of Philadelphia, and the Vice-President is Henry W. Oliver, of Pittsburgh.

THE Illinois Steel Company has decided to add a new furnace for the manufacture of basic steel to its plant at Joliet, and four furnaces and one plate mill to its plant at South Chicago, thus largely increasing the capacity of its works.

THE Cedar Point Furnace, Port Henry, N. Y., has gone into blast after a rest of two years. This furnace uses ore from the mines of Witherbees, Sherman & Company at Mineville, N. Y.

THE Pittsburgh Steel Casting Company is about to make an extensive addition to its equipment. Work will begin at once on a Bessemer steel plant in connection with their foundry, so that they can make Bessemer steel castings up to 16,000 lbs. in weight. An eight-ton converter will be erected, and the new plant will probably be in operation early in April.

THE North Carolina Steel & Iron Company has been organized at Salisbury, N. C., and will begin operations by building a blast furnace of 150 tons daily capacity at Greensboro, N. C. This will be followed by a Bessemer steel plant and rolling mill. The Company has secured lands near Greensboro, where magnetic iron ore is found in large quantities. Among the incorporators are George S. Scott of New York, President of the Richmond & Danville Railroad Company, and James G. Pace of Richmond, Va.

THE Pond Engineering Company, St. Louis, Mo., has the contract to furnish two Armington & Sims engines of 100 H. P. each to the Electric Street Railroad Company at Vancouver, B. C.; also an engine of the same power to the Electric Light Company at Dixon, Ill. This company has recently shipped four 80 H. P. boilers, two boiler feed-pumps, two Blake condensers to Mexico; also an Armington & Sims engine of 50 H. P. to the water-works at Holden, Mo. The Company has recently sold a number of small vertical boilers in the Southwest. Other recent contracts of this Company include a Blake mining pump of large size to the Shotwell Mining Company; a 100 H. P. heater to the Gay Building, St. Louis, and a complete 80 H. P. plant for Murphysboro, Ill., including an Armington & Sims engine, boiler, heater, pump, etc.; also a 200 H. P. compound condensing Armington & Sims engine for the Thompson-Houston Company, stationed in Omaha, Neb.

DURING October the Westinghouse Machine Company in Pittsburgh sold 35 junior engines corrugating 1.095 H. P.; 32 standard engines of 1,395 H. P.; 43 compound engines of 3,545 H. P., making a total of 110 engines of 6,035 H. P. in all.

THE firm of Forsythe & Company, of New York, has succeeded to the business formerly conducted by Herrick & Bergen and the Gardner Company, and now manufactures the perforated veneer seats, panelings, head linings, etc., which was so well known and so widely used in the Gardner patent.

THE Parsons Block, Switch & Frog Company of 29 Broadway, New York, has delivered one of its frogs and switches to the Superintendent of the Brooklyn Bridge, and they have been put in operation upon a cross-over on the Brooklyn end of the bridge. The switch and frog will there receive a very thorough test, as more than 4,000 cars a day pass over this frog and switch, the traffic being almost constant.

Cars.

THE Consolidated Car Heating Company, Albany, N. Y., has absorbed the Automatic Car Coupler Heating Company of Detroit, Mich., and has acquired the ownership of the "Peerless" coupler and other valuable appliances for steam heating.

THE Ohio Falls Car Company, Jeffersonville, Ind., has recently taken the contract to build 22 passenger cars and 1,200 freight cars for the Central Railroad of Georgia. These works are now very busy and are turning out 2 passenger cars a week and 22 freight cars a day.

THE Central Railway Supply & Construction Company has been organized at Indianapolis, Ind., to manufacture and deal in railroad equipment. The capital stock is $350,000.

THE Michigan Car Company, Detroit, Mich., is building 300 box cars for the Flint & Père Marquette Railroad.

THE Haskell & Barker Car Works at Michigan City, Ind., have taken a contract to build 500 coal cars for the Columbus, Hocking Valley & Toledo Railroad.

Marine Engineering.

THE Sheridan Iron Company of Champlain, N. Y., has taken the contract to build a boat for the steam ferry at Port Henry, N. Y. The boat will be a double-screw vessel, 75 ft. long and 30 ft. beam, modeled after the new ferry-boat *Bergen*. She will have a triple-expansion engine of 75 H.P., and is to make not less than eight miles an hour.

THE new steamer *Orizaba* was recently launched from the Roach Yard at Chester, Pa., for the New York & Cuba Mail Steamship Company. The *Orizaba* is of steel 340 ft. 6 in. long over all, 43 ft. 3 in. beam, and 22 ft. 10 in. depth of hold. She will have large accommhdations for passengers. The engines are of the triple-expansion type with cylinders 28 in., 44 in., and 70 in. diameter and 48 in. stroke. The screw is of brass 15 ft. 6 in. in diameter. The boilers are cylindrical, 12 ft. in diameter and 11 ft. 6 in. long, and will carry a working pressure of 160 lbs. Another vessel of the same size is to be begun immediately in the same yard.

THE new steamer *Charlotte* for the Baltimore, Chesapeake & Richmond Steamship Company was recently completed in the yard of Neafie & Levy in Philadelphia. The vessel is of iron, 243 ft. 4 in. long over all, 24 ft. beam, and 24 ft. in depth. She has a triple-expansion engine with cylinders 21 in., 31 in., and 55 in. in diameter and 36 in. stroke; with a four-bladed propeller 12 ft. diameter and 14 ft. pitch. There are two Scotch boilers 13 ft. diameter and 14 ft. long, each having three corrugated furnaces 44 in. diameter and 11 ft. long, furnished by the Continental Iron Works. The boilers will carry 160 lbs. working pressure. The *Charlotte* is to run between Baltimore and West Point.

THE hydraulic steamer *Evolution*, built on the plans of Dr. W. M. Jackson, of New York, was recently launched at the yard of James Lennox at Brooklyn. This vessel is to be propelled on the water-jet system, and her machinery consists of a Roberts tubular boiler and of a duplex compound Worthington steam pump. Working at its full capacity this pumping engine will deliver 1,000 gals. of water a minute through a nozzle $\frac{13}{16}$ in. in diameter, and this jet of water is expected to propel the vessel. A number of experiments have been made before, both in this country and in Europe, with the water-jet system of propulsion, and the result of this new trial will be awaited with some interest.

Bridges.

THE Central Bridge Works at Peterboro, Ont., have secured contracts for two new iron bridges on the Grand Trunk Railway.

The contract for the bridge over the Kaw River, Kansas City, Mo., has been awarded to the Youngstown Bridge Company, Youngstown, O. The bridge will have three spans, 200 ft. long each and one 175 ft. long, and will have a roadway 20 ft. wide.

THE St. Louis Bridge & Iron Company have recently taken contracts for three iron highway bridges in Illinois, two in Kansas, and one in Missouri.

THE Potomac Bridge Works have purchased property in Frederick, Md., and will put up works there for building iron bridges. H. G. Welty is at the head of the enterprise.

THE Keystone Bridge Company, Pittsburgh, Pa., is at work on a bridge over the Ohio River at Brunot's Island. The bridge will be a little over 3,000 ft. long in 16 spans.

THE Groton Bridge Works, Groton, N. Y., are building an iron bridge of 153 ft. span over the Cattaraugus River at Gowanda, N. Y.

THE bridge over the Lehigh River at Easton, Pa., on the Central Railroad of New Jersey, is to be replaced by a new double-track bridge having two through spans of 160 ft. each and one through skew-span of 175 ft. The new bridge will be built by the Phœnix Bridge Company.

THE Easton & Northern Railroad has let contracts for two

through spans of 112 ft. each and two lattice girder spans of 95 ft. each to the Edge Moor Bridge Works; also for a number of small girder bridges, which will be built by the Union Bridge Company at its Athens shops.

THE Lehigh Valley Company has contracted with the Edge Moor Bridge Works for the bridges on its new extension to Jersey City, as follows: At Roselle one double-track span of 165 ft. across the Central Railroad of New Jersey; at Newark the bridge across the Pennsylvania Railroad, with two double-track spans, one of 175 ft and one of 154 ft.

THE Phœnix Bridge Company has a contract for 2,500 tons of small iron bridges for the Western Railroad of Uruguay. Work has been begun on the material, which is to be delivered on board ship at New York by February 1.

THE contract for the great iron roof of the Madison Square Garden Building in New York has been let by the architects, Post & McCord, to the Phœnix Iron Company.

BOTH the Phœnix Iron Company and the Pencoyd Iron Company are building special plants for making eye-bars. At the former works the buildings for the annealing furnaces and the testing machine are nearly completed, and the parts of the testing machine are in the shops. This machine will have a capacity of 1,000 tons, and will break an eye-bar 9 × 3 in. in section and 60 ft. long without resetting. It is expected to exceed the machines at Athens and at the Watertown Arsenal in capacity.

THE Red Rock Bridge across the Colorado River, now under construction, will contain the largest driven pins in the country, if not in the world. These pins are 15 in. in diameter and 5 ft. 8 in. long, and weigh 3,900 lbs. A pilot-nut 18 in. long and a butt go with the pins for driving. The pin-holes are bored $\frac{1}{16}$ in. large to insure driving, as the pins will have to pass through 4 ft. of metal.

THE Pottstown Iron Company, Pottstown, Pa., recently put its new furnace in blast. In starting the furnace an explosion was caused by moisture, which made a great noise, but fortunately did no serious damage. The Company now has its Bessemer-basic steel plant in active operation.

Locomotives.

THE Schenectady Locomotive Works, Schenectady, N. Y., are building 10 consolidation engines with 21 × 24 in. cylinders for the Chesapeake & Ohio Railroad.

THE Brooks Locomotive Works, Dunkirk, N. Y., have recently built 10 mogul engines with 19 × 26 in. cylinders for the New York Central & Hudson River Railroad. The same works are also building for the Cleveland, Cincinnati, Chicago & St. Louis Railroad five 6-wheeled switching engines with 18 × 24 in. cylinders and 10-wheeled passenger engines with 19 × 24 in. cylinders and 62 in. drivers. The 10-wheeled pattern, by the way, seems to be growing very popular for heavy passenger service. The Brooks Works have recently shipped engines to the Chesapeake & Ohio, the Lake Erie & Western, the Toledo & Ohio Central, and several other roads, and one passenger engine to Cuba.

THE Baldwin Locomotive Works, Philadelphia, are building five freight engines for the Salt Lake & Eastern Railroad.

H. K. PORTER & COMPANY in Pittsburgh are building two light passenger engines for the Salt Lake & Eastern Railroad.

Electrical Notes.

THE West End Street Railroad Company in Boston has recently put in operation the electric cars on the Shawmut Avenue Line and on the line from Park Square to Cambridge. The Arlington and the Brighton lines of the Company have been operated by electric cars for some time. The Company, as has been already stated, purposes continuing the work until all its lines are operated by electricity.

THE Sprague Electric Railway & Motor Company, of New York, has recently closed contracts for equipping street railroads, as follows: Sioux City, Ia., Electric Railroad, 12 cars; Sherman, Tex., College Park Electric Belt Line, 5 cars; Newark, O., Electric Railroad, 1 car; Milwaukee, Wis., West Side Street Railroad, 10 cars; Nashville, Tenn., & Edgefield Railroad, 10 cars; Nashville, Tenn., South Nashville Railroad, 10 cars; Salt Lake City, Utah, Electric Railroad extension, 10 cars; Youngstown, O., Electric Railroad, 6 cars. The Company's works are now very busy on street railroad motors, and new orders and inquiries are constantly received.

Iron Production.

THE *American Manufacturer* gives a statement of the condition of the blast furnaces on December 1, and says: "In a condensed form the showing is as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,226	94	11,725
Anthracite	106	40,228	82	21,907
Bituminous	162	113,501	82	38,416
Total	337	166,955	258	71,048

"As compared with a year ago, there have been some material changes, as will be seen from the following table:

	Dec. 1, 1889.		Dec. 1, 1888.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	69	13,226	73	13,270
Anthracite	106	40,228	107	31,052
Bituminous	162	113,501	151	94,960
Total	337	166,955	331	139,282

"Adding together the capacities of the furnaces in blast for the first six months of the year and the last six months of the year, the result would indicate that there was an increased production in the last six months of the year of 7.6 per cent.

"As the production of the country in the first half of 1889 was 3,667,767 gross tons this would indicate a production of 3,946,517 in the last half of the year, which would indicate a total production for the year of 7,614,284 tons."

Shipments of iron ore from the Lake Superior Region for the season of navigation just closed have been as follows:

	1889.	1888.
Marquette	1,376,335	844,694
Escanaba	3,003,632	1,202,965
St. Ignace	54,853	107,399
Ashland, Wis	1,484,802	1,016,414
Two Harbors, Minn	816,630	450,475
Gladstone	48,250	......
Total	6,805,511	4,631,947

The gain over last season's shipments is 2,182,564 tons, and the total brings the quantity sent to market by water up to a figure that leaves no doubt that the shipments by rail will carry the output of the mines for the year above 7,000,000 tons. The year just ended has been a notable one in the history of iron mining on Lake Superior.

OBITUARY.

H. B. KITTENDORF, who died in New Haven, Conn., December 12, was for a number of years Master Mechanic of the New York, New Haven & Hartford Railroad. He retired from that position several years ago and has since been connected with the New Haven & Derby Railroad. He was 62 years old.

EDWARD N. DICKERSON, who died in Rockaway, N. Y., December 11, aged 53 years, was for many years one of the best-known patent lawyers in the country. He studied law and practised it for a time, but afterward traveled, and on his return home devoted himself to scientific and mechanical studies. His controversies with Chief Engineer Isherwood during the war, in relation to working steam expansively, will be remembered by many. After the war he returned to the bar and was engaged in many important cases, the latest being the "Bell Telephone."

THOMAS A. WALKER, who died in London recently, aged 60 years, was one of the best-known English Railroad contractors. He was for a number of years connected with Mr. Brassey, the great contractor, as an Engineer, and in that capacity built part of the Grand Trunk Railroad and the Nova Scotia Railroad, and was engaged on several Russian roads. Later he superintended the construction of a large part of the underground railroad lines in London, and had charge of other important works. At the time of his death he was contractor for the Manchester Ship Canal.

FRANKLIN B. GOWEN died suddenly in Washington, December 14, under circumstances which lead to the belief that he committed suicide, although it is possible that he might have been killed by the accidental discharge of the pistol in his own hands. Mr. Gowen was 53 years old, was born in Philadelphia, and was by profession a lawyer. He made his mark as prosecutor of Schuylkill County, Pa., when still a young man, and in 1862 he was made Counsel of the Philadelphia & Reading Railroad Company. In 1870 he was elected President of that Company and held the office until 1886, with the exception of the year 1881, when he was defeated by Mr. Frank S. Bond, and retired for a year, returning, however, to the presidency in 1882. Mr. Gowen made a high reputation as a lawyer by conducting the famous "Molly Maguire" trials, which broke up the system through which the coal mining regions of Pennsylvania had been terrorized. While President of the Reading Company he became one of the best-known men in the country, but while his administration was brilliant, it cannot be called successful, since it ended in the bankruptcy of the Company and a receivership. He conducted the first reorganization, but afterward retired from the management of the road, and has since taken no active part publicly, although he had continued to practise law. No cause can be assigned why he should have committed suicide.

PERSONALS.

ANTHONY JONES has resigned his position as Chief Engineer of the Long Island Railroad, after seven years of service with the Company.

C. C. MALLARD has been appointed Assistant Superintendent of bridges and buildings of the Southern Pacific Company's Atlantic Lines.

MAJOR E. T. D. MYERS, for a number of years past General Superintendent of the Richmond, Fredericksburg & Potomac Railroad, has been chosen President of the Company.

M. J. MCINARNA has been appointed Road and Bridge Inspector by Railroad Commissioner Cappeler of Ohio. He was recently Roadmaster of the New York, Pennsylvania & Ohio Railroad.

C. E. HENDERSON has been appointed General Manager of the Philadelphia & Reading Coal & Iron Company, with office at Pottsville, Pa. He was recently General Manager of the Ohio, Indiana & Western Railroad.

WILLIAM P. SHINN has retired from his position as Vice-President and General Manager of the New York & New England Railroad Company after three years of service in that position. Mr. Shinn's administration has been very successful.

HORACE SEE, formerly connected with Cramp & Sons in Philadelphia, has opened an office as Consulting Engineer at No. 1 Broadway, New York. Mr. See's ability and experience as a mechanical and marine engineer are well known.

E. J. BLAKE, formerly Chief Engineer of the Hannibal & St. Joseph Railroad and of the Kansas City, St. Joseph & Council Bluffs Railroad, has been appointed Chief Engineer of the Chicago, Burlington & Quincy Railroad, taking the place of GEORGE C. SMITH, who has resigned.

F. W. DEAN, the well-known mechanical engineer, announces that he is prepared to furnish designs for compound locomotives and high-pressure boilers adapted to any kind of railroad service; also designs for converting existing locomotives into compounds. Mr. Dean's office is at 27 School Street, Boston.

CLEMENS HERSCHEL has resigned his position as Engineer of the Holyoke Water Power Company, and will go to Newark, N. J., where he will have charge of the construction of new water-works. Mr. Herschel is well known as a Hydraulic Engineer, and has served as Consulting Engineer for many important enterprises. He was at one time a member of the Massachusetts Railroad Commission.

CHARLES HOWARD has been appointed General Manager of the New York & New England Railroad, succeeding Mr. William P. Shinn, who has resigned. Mr. Howard served on the old Boston, Hartford & Erie Road a number of years ago, and has since been Superintendent of the Cincinnati, Sandusky & Cleveland and of the Danville & Ohio River roads, General Manager of the Worcester, Nashua & Rochester, and Manager of the Providence & Worcester Railroad.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting in New York, November 20, a paper by Edmund B. Weston on the Result of Investigations Relating to Formulas for the Flow of Water in Pipes was read. A written discussion was also read by Rudolph Hering on this paper, and the paper was discussed verbally by Messrs. Brush, Freeman, Emery, and Fteley.

AT the regular meeting in New York, December 18, a paper by Franz A. Veschow on the Causes of Trade Winds was read, and was discussed by the members present.

THE 37th annual meeting of the Society will be held in New York, January 15, at 10 A.M. The annual reports and reports of the standing committees will be presented, officers elected, time and place for the annual convention considered, and other business transacted.

It is expected that the business will be completed on the first day. Arrangements for the second day, January 16, will be announced by the Local Committee.

Boston Society of Civil Engineers.—At the regular meeting in Boston, November 20, the Committee appointed to confer with the Committee of the American Society presented a report favoring some plan of union, and giving a summary of the correspondence had with the American Society.

A paper on the Freezing Process of Making Excavations in Wet Ground was read by Mr. E. S. Abbott.

New England Water-Works Association.—The regular quarterly meeting was held in Boston, December 11, with a very large attendance. The following members were elected: Elmer E. Farnham, Sharon, Mass.; John C. Haskell, Lynn, Mass.; W. H. Vaughan, Wellesley, Mass.; Charles F. Parks, William Wheeler, Boston, Mass.; John W. Ellis, Woonsocket, R. I.; William E. Davis, Sherburne, N. Y.; Samuel B. Leach, Tarrytown, N. Y.; Professor J. E. Denton, Hoboken, N. J.; H. J. Koch, Aspen, Col.; E. P. Foster, San Buenaventura, Cal.; Edward M. Boggs, San Bernardino, Cal.; C. H. Tompkins, Jr., Boisé City, Idaho.

Mr. J. R. Freeman then read a paper on experiments and practical tables relating to the Discharge of Fire-streams, and the Loss of Pressure by Friction in Hose. In this paper he argued in favor of the increase in the standard size of fire hose, and also in favor of larger water mains in districts occupied by factories and other large buildings. This paper was discussed by the members present.

Engineers' Club of Philadelphia.—At the regular meeting in Philadelphia, November 16, Mr. William B. Spence, visitor, exhibited a working model of the Rimmer Oxidizer, a filtering material, which he described, and for which he made various claims as to its utility in the purification of water by oxidation.

Mr. Spence stated that the material used is an English invention and that it is known as Magnetic Carbide of Iron. It consists of a mixture of granulated iron ore and carbon. The iron ore is said to be cleaned of all natural impurities by a patented process. It is then chemically treated at a certain temperature.

To illustrate the destruction of organic matter, sulphide of ammonia, sulphide of iron, and acetate of lead were added to water, making a compound which was almost black and of strong and unpleasant odor. After filtration it was clear, and tests seemed to fail to discover any trace of the impurities.

A mixture of copying ink and water was passed through the filter with the same results.

The entire balance of the evening was spent in making inquiries and in the discussion of this apparatus.

A REGULAR meeting was held in Philadelphia, December 7. The Committee on Highway Bridges reported no further business before it and was discharged. A Committee was appointed to arrange for a Club Reception on the anniversary of the organization. Nominations were made for officers for the ensuing year.

Mr. George Burnham, Jr., described the spirally-welded steel tubing made at East Orange, N. J., exhibiting a length of pipe 10 in. in diameter by 9 ft. 5 in. long. (The method of making this tubing was described in the JOURNAL for March, 1889, page 118.) This contribution was discussed at some length.

Mr. A. P. Brommell presented an illustrated paper upon a new system of street-car propulsion. This paper also was discussed at some length.

Franklin Institute.—The programme of lectures for the month of January is as follows:

January 6: Chemistry of Coal, by Professor F. W. Clarke.
January 10: [New Applications of Photography, by John Carbutt.
January 13: A Revolution in Dyeing, by Professor R. L. Chase.
January 17: Mammoth Cave of Kentucky, by Professor W. Le Conte W. Stevens.
January 20: Electricity in Warfare, by Lieutenant Bradley A. Fiske, U. S. N.
January 24: Inheritance of Acquired Characters, by Dr. Edward D. Cope.
January 27: Color-blindness, by Dr. W. Thompson.
January 31: Sketches of Germany, by C. J. Hexamer.

Civil Engineers' Club of Cleveland.—At the semi-monthly meeting, November 26, the discussion of the subject presented by Mr. Bartol at the last meeting—Recent Developments in Steel and Iron Manufacture—was resumed.

It was pointed out that the difference between iron and machinery steel of to-day is due to the difference in the mode of manufacture rather than to chemical composition. The steel having been melted and cast into ingots was in a homogeneous state; while iron is made by puddling, which is really the welding together of the particles into a spongy mass, which is compacted by hammering or rolling.

The relative merits of iron and steel for structural purposes were discussed, and the advantages of soft steel dwelt on. It was claimed that most of the trouble with steel had come from using inferior grades. In order to compare tests of steel it is necessary that the test-pieces have the same length of test-section. For this reason it is very desirable that a standard length of test-piece be adopted by engineers. Most specifications require 8 in. of section, but it was stated on good authority that 4 in. or four times the breadth was used in steel works and considered to possess all requirements for a standard length of section, besides being less expensive than the 8 in.

Mr. W. B. Wood then read a paper on Facts and Speculations Regarding the Planet Mars, which was followed by a discussion, its canals and satellites being dwelt on. President Warner's paper on Astronomical Photography, which followed, was illustrated by an enlarged photograph of the moon taken by the Lick Telescope. In the discussion the process was described by which the heavens are being photographed and mapped by the co-operation of the astronomers.

At the regular monthly meeting, December 10, Herman Pool, W. B. Cleveland, and Royal Gurley were elected active members; Hiram A. Tucker, associate member.

Dr. Mabery, Professor of Chemistry, gave a lecture on Development of the Color Industry from Coal-tar Products, which was illustrated by specimens of colors and experiments. The Egyptians used indigo for coloring in prehistoric times. The best coloring, however, is got from indigo made from coal-tar products. So great is the variety of dyes made from the products of coal-tar that now every color and shade is made from them.

Engineers' Club of Cincinnati.—At the regular meeting, November 21, the date for holding the meetings was changed to the third Thursday in each month. There being no special subject for discussion, Mr. Nicholson gave an interesting account of his experience in driving piles for trestles in the neighborhood of New Orleans, describing also the difficulties met with in the erection of buildings and their structures in and around that city on account of the marshy nature of the soil on which it is built.

Engineering Association of the Southwest.—This Society has been organized with headquarters at Nashville, Tenn. The membership is intended to include engineers in Tennessee, Kentucky, Mississippi, Alabama, and Georgia, who are not attached to other associations.

The first meeting was held in Nashville, November 21, when it was decided to hold meetings on the second Thursday of each month in that city. The following officers were elected: President, John McLeod, Louisville, Ky.; First Vice-President, W. F. Foster, Nashville, Tenn.; Second Vice-President, Edwin Thacher, Decatur, Ala.; Secretary, Olin H. Landreth, Nashville, Tenn.; Treasurer, W. L. Dudley, Nashville, Tenn. It is expected that permanent headquarters will shortly be provided for the Association.

At the regular meeting in Nashville, Tenn., December 12, Mr. Edwin Thacher read a paper on the Use of Slide Rules by engineers and architects. This paper was discussed by members present.

Arkansas Society of Engineers, Architects & Surveyors.—The annual meeting was held in Little Rock, Ark., November 12, 13, and 14, w[illegible] a large attendance. The programme was well arranged by [illegible]he Local Committee, who provided entertainments for the v.sitors. Among the papers read were the following: J. B. Gass on Fort Smith Sewerage; A. B. Matson on Municipal Improvement of Texarkana; W. E. Anderson on Highway Building; E. C. Buchanan on Miscellaneous Matters; R. D'Ailly on Forestry; H. G. Martin on Rights, Duties, and Responsibilities of Surveyors, and F. W. Gibb on Mineral Resources of Arkansas.

Western Society of Engineers.—At the regular meeting in Chicago, November 6, John E. Frohlund, Fremont Hill, and George W. Waite were elected members. Mr. A. Gottlieb was chosen representative of the Society on the Board of Managers of the Associated Engineering Societies.

Mr. Liljencrantz then read a paper on Compound Lumber, describing the works of the Compound Lumber Company at Burnham, Ill. This compound lumber consists of a core of soft wood, usually pine, faced with certain varieties of hard wood as desired, the facing being tenoned and grooved upon the core. This was discussed by members present.

Discussions on the Chicago Drainage Problem being then in order, Mr. H. A. Stoltenberg presented a paper giving his reasons against the Desplaines River plan, and stating that the best solution would be a system of intercepted waterways along both banks of the river and its branches, as suggested a number of years ago. The plan, he thought, would cost about $5,500,000, and the work could be completed in two years. Mr. R. B. Mason also presented a written discussion in favor of the system of drainage by the Desplaines River. Mr. L. E. Cooley reviewed both papers, opposing both their plans.

Engineers' Club of St. Louis.—At the regular meeting, November 20, amendments to the by-laws were adopted. A Committee to nominate officers for the ensuing year was appointed.

Mr. Robert Moore then read a paper on Railroad Culverts, describing the various forms of culvert used, with advantages and disadvantages of each, and presenting a diagram for determining the size of culvert required. The paper was discussed by a number of members present. In the discussion it was stated that iron pipes as large as 6 ft. in diameter were made for this purpose.

A regular meeting was held in St. Louis, December 4. R. S. Comlon was elected a member.

Mr. Robert Moore submitted a report from the Standing Committee on Collection of Local Engineering Data. The information furnished the Committee was of great and permanent value. Those contributing were T. B. McMath, C. V. Mersereau, S. F. Burnet, T. J. Caldwell, R. E. McMath, F. E. Nipher, J. A. Seddon, E. D. Meier, and M. L. Holman. Some data on Fuels was in preparation by Professor Potter, but had not been completed in time for this report. It was ordered that the Committee be continued and requested to present a final report as soon as convenient.

The Special Committee on Nominations of Officers for the coming year reported as follows: For President, F. E. Nipher; Vice-President, George Burnet; Secretary, W. H. Bryan; Treasurer, Charles W. Melcher; Directors, E. D. Meier and S. B. Russell; Librarian and Manager, J. B. Johnson; Manager, J. A. Seddon.

The report was accepted and the following additional nominations were made: For Vice-President, S. B. Russell; for Director, F. H. Pond.

Annual reports were received from the Secretary, Librarian, and Treasurer, and an invitation was extended to Professor T. C. Mendenhall, Superintendent of the Coast Survey, to address the Club, and to attend a banquet given in his honor.

Mr. N. W. Perkins, Jr., read a paper on Adding Machines, which treated particularly of one invented by W. R. Burrows, of St. Louis, one of which was shown. The subject was discussed by members present.

Tacoma Society of Civil Engineers & Architects.—This Society has been organized at Tacoma, Washington, and starts out with 42 members. The officers are: President, H. S. Huson; Vice-President, Arthur L. Smith; Treasurer and Librarian, Charles F. White; Secretary, William S. Gosslyn.

American Boiler-Makers' Association.—This Association, which was organized last spring, held its first annual Convention in Pittsburgh, beginning November 16. The meeting lasted two days, and about 100 members were present, representing boiler-manufacturing interests in all parts of the country. The President, Mr. James Lappan, of Pittsburgh, occupied the chair. Reports were submitted by the officers showing that the Association had started off prosperously and was well prepared for work.

The nature of the business transacted will be understood from the list of reports submitted by the special committees. These reports were on Material for Boilers; on Bracing, Stays, and Proper Tube Spacing; on Attachment of Valves and Valve-fittings; on Manheads and Manholes; on Proper Rules for Riveting and Calking; on Comparative Value of Mechanical and Hand Riveting. The Committee on Material recommended careful tests of boiler plate, especially of steel plate, and also reported against the use of cast-iron for mud-drums, legs, necks, etc., etc.—that is, any part of the boiler where it is subject to tensile strains. The use of steel castings was recommended for manhole rings and similar purposes.

It was decided to hold the next meeting in New York in July, 1890. At that meeting reports will be submitted on Safety Valves, and Horse-Power; on State Inspection Laws; and on Statistics. The Association starts out well, and is expected to be of much practical service.

New York Naval Reserve.—The First Battalion of the Naval Reserve of the State of New York has been fully organized at two preliminary meetings, at which a considerable number of persons interested were present. The battalion under the law will form part of the State Militia. It will be commanded by Philip B. Low, who will have the naval rank of Lieutenant Commander, and will be composed of four companies, which will be commanded respectively by George E. Kent, F. R. Colvin, L. M. Mowbry, and W. P. Williams. All the officers are graduates of the Naval Academy at Annapolis and have seen service in the Navy. Active work will be begun at once in the instruction of the men, and, as opportunity permits, this will be extended to torpedo management, gunnery, and the handling of vessels. It is expected that the Navy Department will, as soon as possible, furnish the battalion with a training ship for part of the year.

New York Railroad Club.—The annual meeting was held in New York, November 21, and arrangements were made for the meetings during the winter season. It was stated that a number of prominent railroad men had agreed to give the Club their support, and that the prospect for a series of interesting meetings was very good. The following officers were elected for the ensuing year: President, Ross Kells; Vice-Presidents, R. C. Blackall and W. L. Hoffecker; Secretary, L. R. Pomeroy; Treasurer, C. A. Smith; Executive Committee, H. Tandy, W. C. Ennis, Thomas Aldcorn, W. H. Lewis, J. W. Baker, Thomas Millen, H. S. Hayward, and H. A. Webster.

Northwest Railroad Club.—At the regular meeting in Minneapolis, December 7, the subject for discussion was the Purification of Feed-Water. It was opened by Mr. J. L. Pattee, who read a paper giving many analyses of water. Shorter papers were read by Messrs. W. T. Reed, C. N. Hunt, and McIntosh. Mr. Hunt presented the merits of the Fields feed-water purifier, and the subject was further discussed by members present.

Western Railway Club.—A regular meeting of this Club was held in Chicago, December 17. The first subject discussed was Joint Inspection, opened by Mr. P. H. Peck.

The second subject was Testing Laboratories. Both subjects were discussed by members present.

New England Railroad Club.—At the regular meeting in Boston, December 11, Mr. R. H. Soule read a paper on Signals and Signaling. Mr. Soule gave a brief sketch of the progress of signaling in this country, and then spoke of the use of the semaphore and its different varieties. He described the different methods of making connections, and spoke on the interlocking system and the rules governing it, and of the importance of that system. He described the Saxby & Farmer system and others which have been used, and he referred to some of the large signal systems now in use in this country, including the interlocking apparatus at the Grand Central Station in New York; the New Jersey Central Yard in Jersey City, and others. He also spoke of the different connections used, by electricity, by wires, and the electro-pneumatic apparatus, a number of which are in use in Pittsburgh, Kansas City, and elsewhere. After describing the block signaling system he referred at some length to the economy secured by recent practice and by concentration of apparatus.

The subject was further discussed by members present.

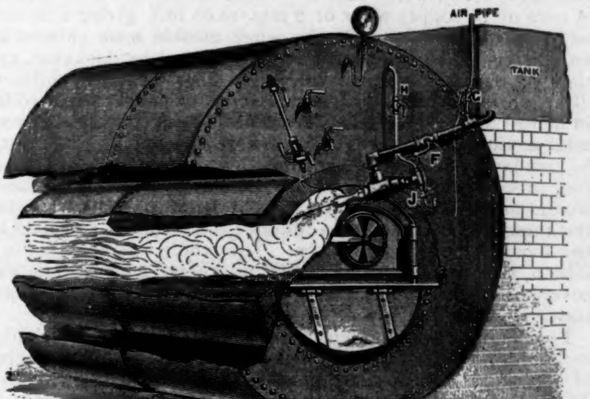
NOTES AND NEWS.

A New Mountain Railroad.—Among the many adventurous undertakings of modern times, the proposed railroad to the summit of the Jungfrau, in Switzerland, is the most remarkable. The engineers who have prepared the plans, however, have before them the success which has attended the opening of similar lines, for instance, the Rigi Railroad, the Montreux Railroad, the Pilatus Railroad, and last, not least, the Vesuvius Railroad, besides other lines of minor importance. But all those mentioned may be considered child's play compared with the line now proposed. The Jungfrau has an elevation of over 13,000 ft., and its upper slopes are eternally covered with ice and snow, excepting those parts too steep for snow or ice to hold on to. A Swiss engineer, Herr Köchlin, of Zürich, however, has demonstrated the practicability of the railroad, and sent to the Swiss Federal Council an application for a concession. The line proposed starts from the Lauterbrunnen station of the Interlaken & Lauterbrunnen Railroad, now building, and is to be altogether about six miles long. It is divided into two sections, the valley line, which is comparatively easy of construction, and the mountain railroad proper. The latter is to be either a rack-rail line or a wire-rope railway in five stages, placed one above the other. The rise of the rack railway would be 1 in 2, and for working such a steep gradient it is proposed to use electricity, the current being conveyed along the rack-rail. Should wire-rope traction be adopted, hydraulic power would be used, in a very simple manner, a carriage weighted with water descending, and hauling up, by a wire-rope, another carriage on an adjacent line. This is the system employed at the Montreux Railroad, where the rise in some portions is as much as 1 in 1½. The length of the mountain line would be 3½ miles. To protect the railroad in the more exposed portions, it would run there in tunnel, the longest tunnel being near the summit. To provide for the accommodation of travellers, a hut of refuge and an hotel, as well as an observatory, are to be established on the summit. It is anticipated that fully 30,000 visitors yearly would avail themselves of the facility offered for ascending the Jungfrau, a mountain full of difficulties, but presenting no danger to experienced mountaineers accompanied by good guides. The cost of construction is placed at $1,950,000, while the annual revenue, supposing the number of travelers were to reach the total estimated, would be $202,500, the fare proposed being 35 francs ($6.75) for the round trip.

Tall Chimneys.—There has just been completed, at the Fall River Iron Works, Fall River, Mass., the tallest smoke-shaft in the United States, described by its owners as "the tallest chimney in the world designed solely for making a draft for boilers." To this statement we must take exception. The chimney in question is 340 ft. high above its granite base, and 30 ft. square at the bottom. It is 5 ft. higher than one at East Newark, N. J., which reaches an altitude of 335 ft., including its bell. There is also one at Boston, Mass., 200 ft. in height, and another at Providence, R. I., 180 ft. high. The "tallest chimney in the world" is that at Townsend's, Port Dundas, Glasgow; in fact, three higher stacks exist in this country than that at Fall River. They were, however, constructed for carrying off noxious fumes from chemical works, and not for creating a draft for steam-boiler furnaces. These three chimneys are that mentioned at Port Dundas, which is 454 ft. high; Saint Rollox, Glasgow, 436½ ft. in height; and Dobson & Barlow's, Bolton, 367 ft. high. There has also been completed, at Freiberg, Saxony, a very high chimney, intended to carry off blast-furnace gases at the Freiberger Muldenhütten. This chimney has a base 39 ft. 4 in. square, and rises to a height of 443 ft., where it ends in a circular opening 10 ft. in diameter. The Fall River chimney will furnish draft for the boilers of four new factories. It should be added that it requires the highest skilled labor to construct high chimneys, and the slight-

est deviation from fixed rules as to the reduction of diameter, or the failure to construct the cores, extending from the base to the top, would result in the collapse of the whole structure.—*Iron.*

A New Liquid Fuel Burner.—The liquid fuel injector illustrated herewith has been specially designed by its inventor, Mr. Stewart, for firing boilers with liquid fuel instead of coal, or as an auxiliary to coal, and is adopted by proprietors of oil works and others. By using the injector complete combustion, without smoke or smell, is secured, and waste products, as shale, tar, oil, etc., are utilized. The apparatus when started is self-acting, and will burn and keep up steam as long as the fuel supply is continued. Being automatic, one boiler attendant can overlook a large number of boilers. There is nothing complicated to get out of order, and, when fixed and regulated, will work continuously and without any special attention. The injector is also used as an auxiliary where there is not enough boiler power. By using it in this way much better results have been obtained than by using coal alone. The injector is made of gun-metal, the nozzle being of brass, or other metal suitable for resisting the action of acids. The steam-pipe is connected to the nipple at the end of the injector; the brass nozzle is inserted in the front wall of the furnace in a hole above the furnace door, at a slight angle, as shown in our engraving, the orifice being horizontal. The tar or oil feed-pipe is connected to the injector by being screwed into the projecting pap in the body, a branch pipe is attached to the feed-pipe by a **T**-piece, which allows a cock *G* to communicate with the atmosphere, and so allows air to pass in with the liquid fuel. The steam, tar or oil, and air are controlled by cocks or valves on the several pipes. *H* represents the steam-cock on the steam-pipe, and one method of connecting it to the boiler. *F* is the fuel supply-pipe and cock; *G* the air cock; *J* a pet cock attached for discharging condensed water when the injector has been shut and standing. The ordinary furnace bars are covered over with dross, and the air supply is regulated by a ventilator-valve in the furnace door and the air pipe *G*. The action of the injector may be described as follows: Cocks *H* and *J* being opened, steam blows through and clears the pipes of condensed



steam; *J* is then shut off and steam blows through the nozzle. The fuel and air cocks *F* and *G* are now opened and regulated, and a mixture of steam, oil or tar, and air passes through into the furnace or combustion chamber in a highly inflammable state; and, being ignited by the fire in the furnace, burns with an intense heat, which can be so regulated by the fuel and air supply as to consume all the products of combustion, and thoroughly prevent smoke. If such a strong heat is not required, it can be regulated and moderated to any extent required by the controlling cocks and valves for regulating the supply. The apparatus is made by Messrs. P. & W. MacLellan, 129 Trongate, Glasgow, Scotland.—*Iron.*

Submarine Torpedo-Boats.—The Spanish submarine torpedo-boat *El Peral*, has recently completed a series of underwater trials at San Fernando Arsenal, near Cadiz. The preliminary trials of this little vessel took place in March last, but were rendered nugatory through a serious mishap to the machinery. The recent trials, however, have been so far satisfactory that further experiments are to be carried out before a Naval Commission. If the experiments prove successful, a number of these vessels will be constructed for the coast defense of Spain. The boat was designed by Lieutenant Peral of the Spanish Navy, and is a cigar-shaped vessel of 87 tons' burden, propelled and manœuvered by four screws driven by powerful electrical machinery. The current is supplied by accumulators calculated to admit of a continuous run of 326 miles.

The French naval authorities have also been investigating the properties of submarine vessels, and a boat of this type, invented and designed by M. Goubet, has recently been introduced into the French Navy. It is of extremely light construction, and attached to the bow is a pair of curved shears several feet in length, to be used in cutting away the net defenses in an attack upon an iron-clad. The torpedo is attached to the hull of the boat on the outside, and can be disengaged at the will of her commander. The motive power in this craft is also electricity.—*Nautical Magazine.*

A Military Exhibition.—It is proposed in England to hold next year a Military Exhibition on a pretty extensive scale in the grounds of the Royal Hospital, Chelsea. The scope is a wide one, comprising the following sections: 1. Mechanical and military inventions. 2. Models and plans. 3. Freehand drawing, sketching, penmanship, and illumination. 4. Oil and water-color drawings. 5. Photography and lithography. 6. Uniforms and accoutrements. 7. Commissariat, transport, and camp equipment. 8. Ambulance. 9. Arms and ammunition. 10. Metal work. 11. Wood-carving, turning, fretwork, and joinery. 12. Saddlery and leather work. 13. Tapestry and needlework. 14. Decorative design in leather and paper. 15. Military music. 16. Musical instruments. Manufacturers' exhibits will be received in Sections 1, 5, 6 7, 8, 9, 12, and 16. Competitions will be held in machines for the supply of hot tea, coffee, etc., for filters, camp equipments, canteens, and scientific instruments for field service. The Exhibition will be opened about May 1, and last for five or six months. The Honorary Secretary is Major G. E. W. Malet, 140 Palace Chambers, Westminster, S.W., London.—*Industries.*

The Life-Saving Service.—The annual report of the General Superintendent of the Life-Saving Service shows the following:

At the close of the fiscal year the establishment embraced 225 stations, 172 being on the Atlantic, 45 on the lakes, 7 on the Pacific, and 1 at the Falls of the Ohio, Louisville, Ky. Since then three new stations have been established, and seven new stations are now under contract—viz.: Wallis Sands, N. H.; Knobbs Beach, Cuttyhunk, and Point Allerton, Mass.; Fort Point and Point Reyes, Cal., and Point Adams, Ore.

The work of the service during the year is summarized as follows: Number of disasters, 528; value of property involved, $6,416,775; value of property saved, $5,054,440; value of property lost, $1,362 335; number of persons involved, 3,426; number of persons lost, 42; number of persons succored, 787; days of succor afforded, 1,726; number of vessels totally lost, 63; number of vessels otherwise aided by crews, 510; number of vessels warned from danger by signals of patrolmen, 217; number of persons rescued who had fallen from wharves, piers, etc, 24.

The assistance to vessels and cargoes, the report says, is still increasing, being greater this year than ever before; but the cost of maintaining the service is somewhat less than last year, being $293,397.

The General Superintendent renews his recommendation of last year for an increase in the pay of the surfmen.

A Remarkable Water Power.—One of the most remarkable instances of electrical transmission of power has only recently been accomplished in the State of Nevada, on the world-famous Comstock Lode and the almost equally famous Sutro Tunnel. At the Nevada Mill there is a 10-ft. Pelton water-wheel, which receives water through a pipe-line delivering water from the side of Mount Davidson under a head of 460 ft., giving 200 H.P. Here the water is again caught up, delivered into two heavy iron pipes and conducted down the vertical shaft and incline of the Chollar Mine to the Sutro Tunnel level, where it is again delivered to six Pelton water-wheels, this time running under a head of 1,680 ft. Each of the six wheels is but 40 in. in diameter, weighing 225 lbs.; but with a jet of water less than ⅝ in. in diameter they develop 125 H.P. each. On the same shafts, which revolve 900 times a minute, are coupled six Brush dynamos, which generate the current for the electric motors that drive the stamps in the mill above ground. The result is that, where it formerly took 312 miners' inches of water to operate 35 stamps, but 72 in. are now required to run 60 stamps. This is the most enormous head of water ever used by any wheel, and by itself constitutes an era in hydraulic engineering. A solid bar of iron thrown forcibly against this tremendous jet rebounds as though it had struck against a solid body instead of a mobile fluid. The speed of this jet, where it

impinges against the buckets of the wheel, is *two miles* a minute —176 ft. a second. . . .

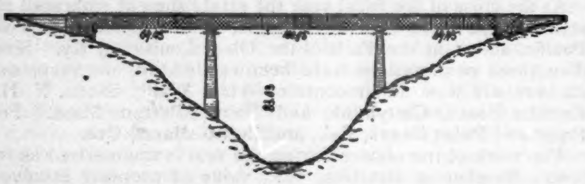
There is another quality of these extraordinary wheels which renders them absolutely without a peer in the large family of prime-movers. This is the immense power exerted per pound of weight. Those in the Chollar Mine, for instance, give out 1 H.P. for every 1.8 lbs. of weight. If there is anywhere a motor which begins to compare with them in this respect, I have never been favored with knowledge of it. And it seems there is no limit, outside of that which sets bounds to the head of water itself, to prevent further progress of the wheel in the same direction.—*Alvan D. Brock, in the Overland Monthly.*

The Tardes Viaduct.—This Viaduct, which was recently completed, and which is described in the publication of the French Ministry of Public Works for 1889, carries the railroad from Mont Lucon to Eyguraude across the valley of the little river Tardes. It consists of two continuous riveted lattice girders resting upon two abutments and two piers, forming a bridge with three openings, the central one being 331.13 ft., and the two side openings, 227.80 ft. span.

The girders forming the bridge are 27.22 ft. in depth, and are spaced 18.04 ft. apart between centers. It is a deck bridge, the track being carried upon the upper chords of the trusses, and in addition to the tracks there is on each side a foot-walk 2.62 ft. in width. The two girders are connected by horizontal and vertical cross-bracing and wind-bracing. The tracks are carried on longitudinal wooden sleepers, which are supported by cross-girders resting upon the upper chord and spaced 8.38 ft. apart.

The height from the surface of the water in the river to the lower chord of the truss is 272.34 ft., and from the river to the level of the track, 299.57 ft. The piers are, respectively, 157.44 ft. and 196.64 ft. in height, and are 26.24 × 14.76 ft. in size at the top. The piers and abutments are built of granite, and the foundations rest upon the bed-rock of the valley, which is very near the surface.

The structure is proportioned to sustain the heaviest lateral pressure possible from the wind, the calculations being based upon observations taken in the neighborhood. The accompanying illustration shows a general view of the bridge. Its total cost was $268,800, including foundations, masonry and superstructure. The bridge was built by M. Eiffel, as contractor, from the designs of the Chief Engineer, M. Daigrembut.



Underground Wires in Paris.—*Le Genie Civil*, in describing the electric light plant at the Halles in Paris, gives an account of the methods used in laying the wires under ground, from which we condense the description below.

The question of laying the cables of the exterior circuit was of considerable interest. The Municipal Council authorized the use of the sewers, but in spite of this the engineers have preferred to build special conduits, and the type adopted seems to solve the problem very well.

Already encumbered as they are, the sewers are not well adapted to new installations of this class. The dampness of them is not favorable to the preservation of the current, and disturbing inductions might result between the electric light cables and the telephone wires. Moreover, accidents to the cable are always to be feared from the negligence, or perhaps even the malice, of the men employed in the sewers; and finally the perfect insulation required would have been exceedingly extensive. The cables, therefore, have been placed under the sidewalks in conduits of the form shown in fig. 1, made of cement and 0.26 × 0.30 m. (10.23 × 11.80 in.) in size. Wooden supports furnished with glass holders, which carry the cables, are placed at distances of 1.50 m. (4.92 ft.) apart. These wooden supports slide freely in grooves made in the conduit, and thus form a method of suspension easily accessible for repairs. In crossing the streets, where the soil is very damp and permeable, cables are sunk one meter below the surface, and the connection with the conduits under the sidewalks is made as shown in fig. 2. At each angle an opening or manhole is provided, as shown in the cut.

For the circuit at low tension the cables are made as follows: the conductors are wires of tinned copper, of number and diameter variable according to circumstances. These wires are twisted together and covered with a layer of pure rubber; then with a layer of mixed rubber at least 2 mm. (0.08 in.), and finally by two bands of cotton impregnated with rubber. The whole cable is vulcanized in a compact mass, and is then protected by an outer covering of hemp soaked in rosin or tar.

For the high-tension circuit, on account of the narrowness of the sidewalk in certain streets, it was necessary to use, for a short distance, the sewers, and in order to avoid any disturbance of the telegraph and telephone wires on these sections, use was made of concentric cables. These cables were thus formed: A core of 19 copper wires of 2 mm. (0.08 in.), giving a section of 60 sq. mm. (9.3 sq. in.); the wires outside were covered by two layers of pure rubber 1 mm. (0.04 in.) in thickness, and then by several layers of vulcanized fiber wound in different directions; outside of this was a series of copper wires rolled in helical form and forming the second circuit, having the same total section as the core. These were covered in turn: First by two layers of pure rubber; then by several layers of vulcanized rubber 3 mm. (0.12 in.) thick; then by two vulcanized bands wound in opposite directions; then by hemp 3 mm. (0.12 in.) in thickness and saturated by a resinous composition, and then by two bands of vulcanized cotton. The whole was enclosed in a leaden pipe 2.5 mm. (0.10 in.) in thickness, which again was covered by twisted cord. This cable rests on wooden supports fastened in the masonry of the sewer.

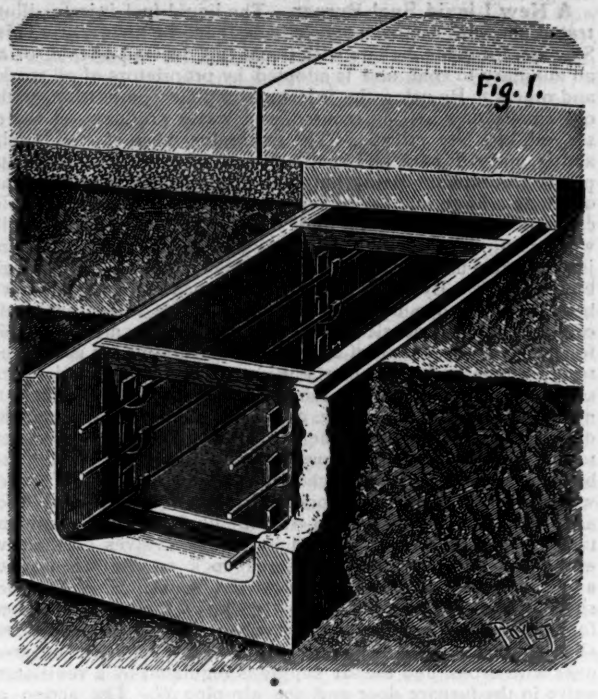


Fig. 1.

For the ordinary high-tension cables the conduits are similar to those for the low-tension cables described above. The degree of insulation was carefully provided for in the specifications. These cables rest on wooden supports injected with sulphate of copper and covered with tar, which rest on porcelain insulators in the cement conduits, as shown in fig. 3. At the crossings of the streets the conduits are arranged as shown above in fig. 2.

Fig. 2.

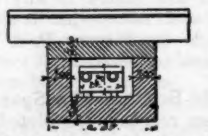


Fig. 3.

The total length of 900 m. (2,952 ft.) of concentric cables in the sewers and 5,800 m. (19,024 ft.) of the ordinary cables was put down at a cost of about $14,800.

The current furnished from the light station is sent out under a pressure of 24 volts. As it is furnished to each user under a tension of 100 volts, it is necessary to use transformers between the main circuit and each side connection.